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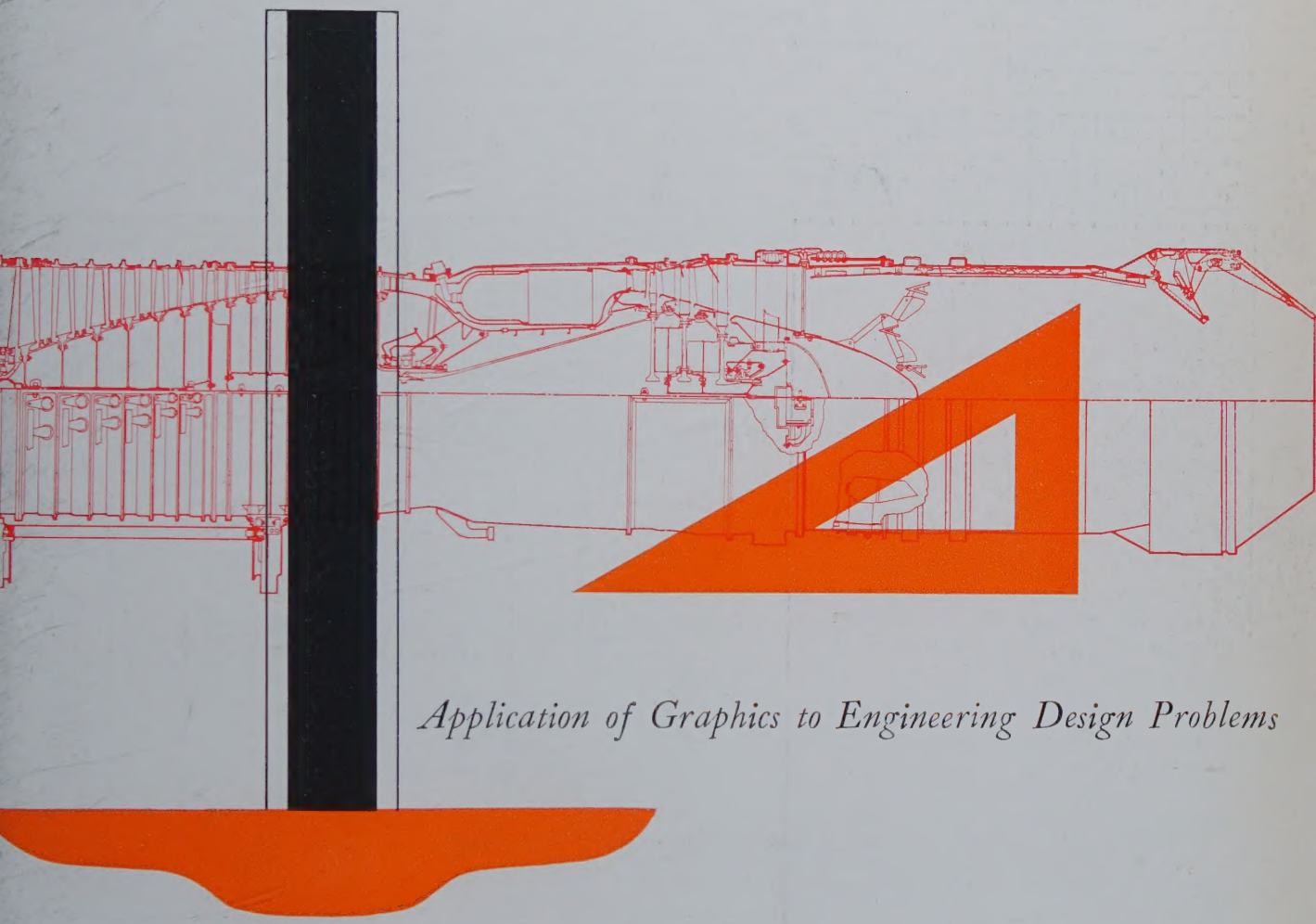

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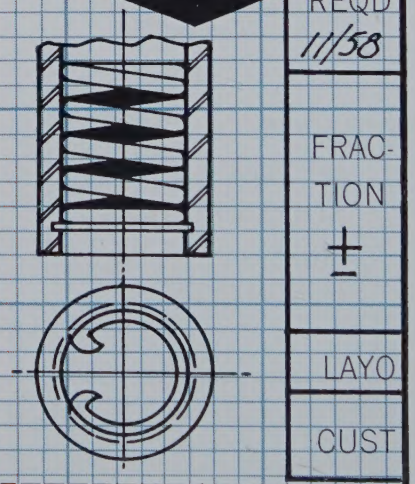

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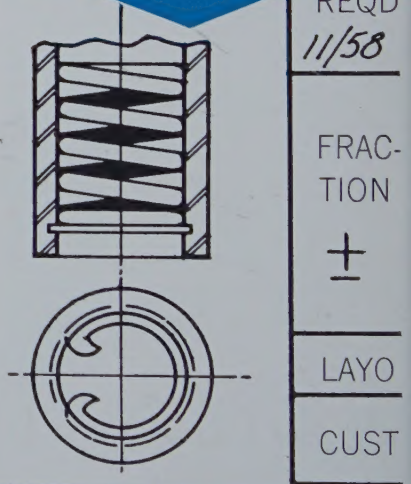

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GRAPHIC SCIENCE

THIS ISSUE 12,000 COPIES

JUNE 1961

VOLUME 3 NUMBER 6

The Magazine Serving Engineering Drawing Management—covering drafting, reproduction and microfilming, technical illustration, drawing standards and engineering documentation.

ARTICLES

DEPARTMENTS

Next Month

FUNCTIONAL DRAFTING, by E. L. Seeland and P. B. Davis

The operations of the draftsman may be made more efficient; they cannot be made "simple." He must convey information in clear, unmistakable terms

A NEW LOOK AT LISTS OF MATERIAL, by D. P. Simonton

A controversial proposal for saving time and money that deserves serious consideration by both industry and government.

GRAPHIC SCIENCE is published monthly by Kinelow Publishing Company, Inc., Wilton Center, Wilton, Connecticut. (POrter 2-5564). Charles E. Rhine, president; Paul Yake, vice president; David Z. Orlow, secretary-treasurer. GRAPHIC SCIENCE is published (printed) at 116 Main St., Norwalk, Conn. Address changes, undeliverable copies, and orders for subscriptions should be sent to GRAPHIC SCIENCE, Wilton Center, Wilton, Connecticut. Postmaster: Form 3579 requested. Subscription rates: $8.00 per year in the United States; $9.00 per year to Canada; $10.00 per year to other countries. Single copies: $1.00.

Accepted as controlled circulation publication at Norwalk, Conn.

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Letters

What Does a Checker Check?

Sirs:

Can you recommend a good book or article on the details of checking drawings?

M. F. McCoy
Engineering Department
Major Appliances
Westinghouse Electric Corporation
300 Phillippi Road
Columbus, Ohio

Editor's Note: We call your attention to the "Checklist for Checkers" published on page 26 of the February 1960 issue of Graphic Science. *Also, maybe some of our readers can help you out on this.*

How They Do It in L. A.

Sirs:

I saw Mr. Taylor's article titled "Do You Want a Promotion?" in the February 1961 issue of Graphic Science, and thought it so well expressed a crying need today, especially to the younger generation, that I took the liberty to underscore certain salient portions of the article, photograph, and reproduce the same and will distribute one copy to each of the 200 and more engineers and draftsmen comprising my staff.

For your own information, I am the chief draftsman of the power design and construction division of the Department of Water and Power of the City of Los Angeles. I believe we are the largest publicly owned, public utility in the free world.

Under my direction we have a supervisor and an assistant supervisor for each of six departments, namely Electrical, Mechanical Steam Plant, General-Mechanical, Structural-Architectural, Civil Topographic, and Clerical. We are a drafting service group for an entirely separate design enginering unit.

We do the drafting from the smallest detail to the largest design layout on all our needed facilities, including miles of steel tower transmission lines such as the three, 3-phase 287,500 volt lines from Boulder Dam to Los Angeles. Also we have designed and built Harbor Steam Electric Generating Plant containing four 65,000 K.W. units plus a 75,000 K.W. unit plus two small house turbines. Recently we completed Scattergood Steam-Electric Generating Station of two units of 156,250 K.W. each.

Each technical working group is composed of draftsmen, layout-draftsmen, senior draftsmen (squad-leader) and engineering - assistants (checker) and all headed by two engineers of associate rank as supervisor and assistant supervisor. The latter reports to the assistant chief draftsman (full engineer), who reports to me, a senior engineer.

Graphic Science Magazine fills a chasm or void of many years' standing.

Louis R. Engel
Chief Draftsman
Department of Water & Power of the
City of Los Angeles
Los Angeles, Calif.

Technical Illustrators Wanted

Sirs:

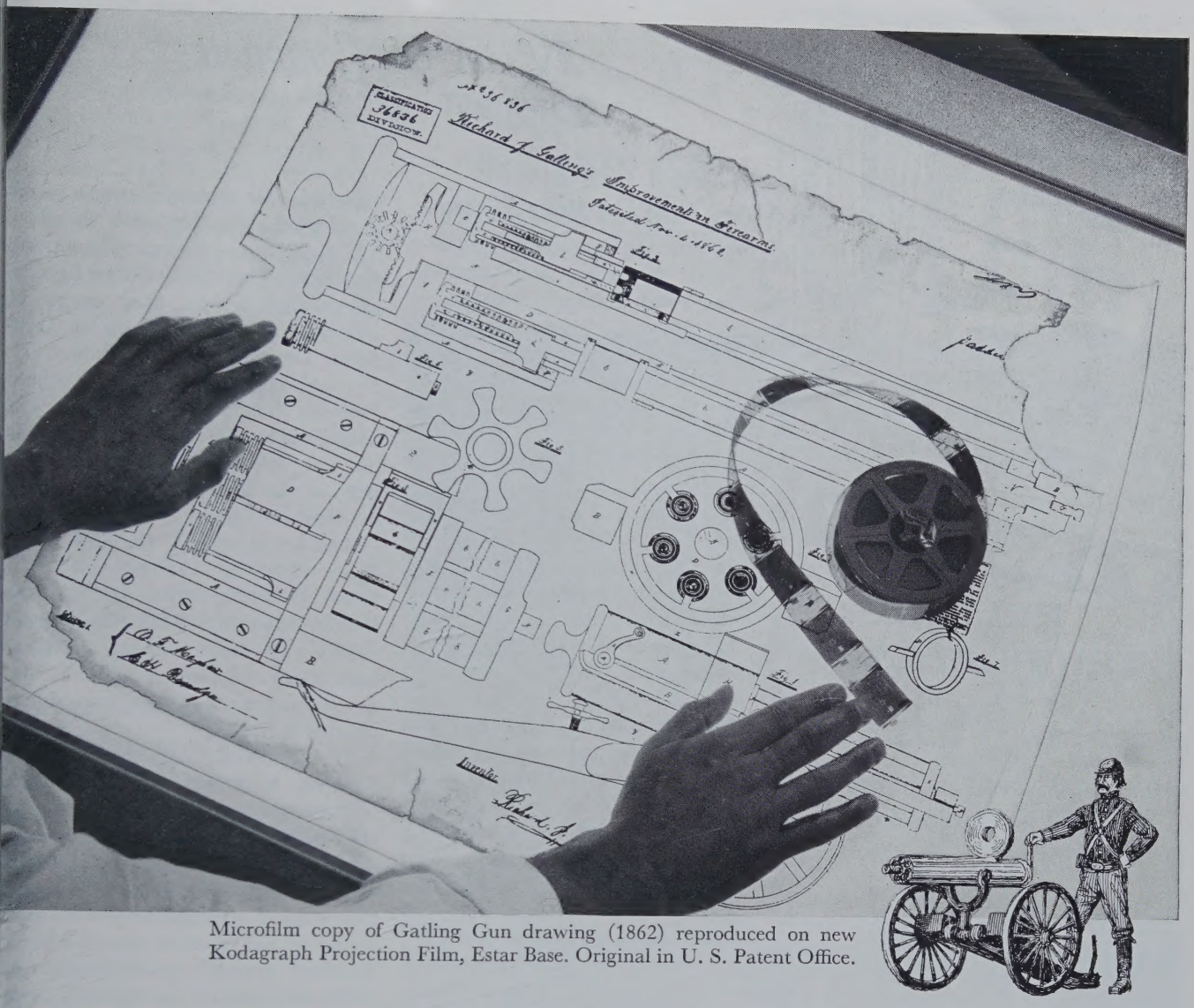
As a result of your publication of the article, "Engineering Illustration Today" in your November issue, Mr. Alexander has received several letters requesting further information. Mostly, the correspondents' requests concern books, schools and training.

It appears that there exists a need for a sort of clearing house for such information and the Society of Engineering Illustrators Inc. is willing to undertake the job. If you would be willing to print a notice to this effect, we are sure a genuine service to your readers would result.

We would like to ask all schools who offer instruction in engineering illustration, technical illustration etc. to send to the SEI as much information as they will, regarding their courses. The SEI, without evaluation or prejudice, will forward this information to those who request it.

The SEI would also like to prepare a book list for similar distribution if publishers, booksellers and book users will help to provide the information.

Lawrence G. Short
President
Society of Engineering Illustrators
100 Farnsworth
Detroit 2, Mich.



Microfilm copy of Gatling Gun drawing (1862) reproduced on new Kodagraph Projection Film, Estar Base. Original in U. S. Patent Office.

Big Blowup from microfilm!

New Kodagraph Projection Film, Estar Base, produces change-in-scale intermediates that will stand up under the heaviest use in drafting room or print-room.

Blowups from microfilm—or reductions of drawings and maps—are remarkably sharp and clean on a whiter base that has a "built-in" longer life.

Production is easy. This new high-contrast, quick-processing film can be exposed in enlarger, projection printer, process camera . . . and handled with "1A" safelight. Wide latitude all but ends make-overs.

See this versatile new Kodagraph Film—and the others in the new *Estar Base line:* Kodagraph Contact Film; Kodagraph Autopositive Film.

All combine reliable Kodak emulsions on the new Estar Base—highly translucent, durable, and dimensionally stable, with excellent matte surface on both sides for easy drafting. Available in standard drawing sheet sizes and in rolls up to 52 inches wide. Call your local Kodagraph Dealer, or write Eastman Kodak Company, Graphic Reproduction Division, Rochester 4, N. Y.

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Notes & Comment

Aero-Space Drafting Manual

THE SAE G-1 COMMITTEE met recently to review and approve the new and revised Aero-Space Drafting Manual. Among the other subjects discussed were military drafting standards and SAE Aero-Auto Drafting Standards.

The SAE Aero-Space Drafting Manual Committee sets an exemplary pattern for all standards activities from the standpoint of thoroughness, excellence of preparation, and cooperativeness in developing agreement.

The committee reported that there is a strong trend toward the adoption of decimal dimensioning as a national standard. Decimal dimensioning was pioneered by the committee in the first edition of its manual in 1942. Satisfaction was expressed on the article, "The Challenge of the Decimal Inch," written by one of its members, P. G. Belitsos of General Electric Co., and published in the April 1961 issue of *The Magazine of Standards.*

The radial concept of true position dimensioning was strongly supported by the committee. The radial concept is widely used by companies experienced with true position dimensioning. The June 1960 SAE Aero-Space Drafting Manual recognizes only the radial system of true position tolerancing. The SAE Drafting Technical Committees feel that industry has a strong stake in keeping important military specifications such as MIL-STD-8B compatible with usable and recognized industrial practices.

In accordance with DoD Instuction 4120.8, dated August 1960, it is acknowledged that wherever possible the military will use recognized industry standards rather than develop new standards. Therefore, the committee recommended that it discontinue work on the Proposed Military Standard DRPR-0031 on gears and that measures be taken to adopt the definitive and up-to-date industry standard in this area. There are several well recognized standards in this area developed by AGMA, ASA, and SAE. The American Standards Association, for example, spent years developing the National Standard Y14.7—1958 on Gears, Splines, and Serrations. There is also a well recognized and widely used series of standards on gears in the SAE Aero-Space Drafting Manual (Section G). In addition, the SAE Aero-Auto Drawing Standards Committee is just completing a series of new standards on gears, splines, and serrations which will be the most advanced standard in industry.

The first edition of the SAE Aero-Space Drafting Manual was published December 1941. At that time it was called the SAE Aeronautical Drafting Manual. Several editions have been released since, and the quality and scope of the manual has steadily increased.

The SAE G-1 Committee is a progressive, hard-working team which has also conducted many worthwhile studies. For example, in a survey conducted in 1947, a test given to groups of engineering employees revealed that it takes approximately five times longer to add fractions than decimals. Another survey was conducted in 1956 to determine the responsibilities of checkers and the ratio of the number of checkers to the number of draftsmen. A 1955 survey proved the unpopularity of simplified drafting. The committee members constantly exchange ideas on drafting organization, administration, procedures, cost control, detailing, documentation, checking, records, standards, etc.

Civil War Drawings

IN RECOGNITION of Civil War Centennial celebrations to be held the next four years throughout the United States, Frederick Post Company is offering a portfolio of Civil War era ordnance prints selected for their historical interest to the engineering profession.

Of special interest to draftsmen and engineers, each print is a reproduction of century-old ordnance. Illustrated on an unusually fine vellum stock, the collection includes line

drawings of field, siege, mountain, and coastal artillery designs in common use during the Civil War.

Prints are historically documented, complete with specifications gathered from War Department records, and are suitable for framing. Print portfolios may be obtained by requesting a Blutex Vellum Appraisal Kit, completing and returning the accompanying appraisal form. Frederick Post Company, 3650 N. Avondale Avenue, Chicago 18, Illinois.

New President for Speidel

DONALD W. MICHAELIS was elected president and chief executive officer of Speidel & Co., Inc., 614 Baltimore Ave., Fernwood, Pa., at the regular meeting of the board of directors. Speidel manufactures and distributes a complete line of reproduction and drafting equipment and supplies.

Hamilton Names New District Representative

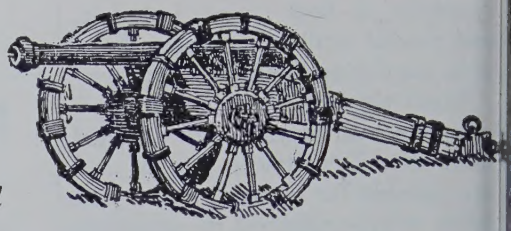
THE APPOINTMENT of Guy V. Sweet, Jr., as Northwest regional representative, has just been announced by Hamilton Manufacturing Co., of Two Rivers, Wisconsin, makers of drafting products. In his new position, Mr. Sweet will operate throughout Idaho, Oregon, Washington, Alaska, and British Columbia. His headquarters: 105 E. 56 Street, Seattle, Washington.

Dictaphone Diversification

DICTAPHONE Corporation has taken another step toward diversification in the business communications industry. In a recent announcement the company revealed its plans to enter the field of facsimile transmission and recording. It will now distribute and service Datafax facsimile equipment made by Stewart-Warner Corporation's Electronics Division. The agreement is non-exclusive.

Free Subscriptions Available

GRAPHIC SCIENCE is expanding its circulation. If you know someone who would benefit from its valuable and informative articles, have them write Circulation Dept., Graphic Science, Wilton, Conn., and ask for an application for a free subscription.



Military Engineering Documentation

by W. S. Hutchinson

NEEDED—BETTER DRAWING COPIES

NEW AND IMPROVED products, such as the new diazo reproducibles now being marketed, offer the military services increased advantage in reproducing drawings and associated engineering data. The NABDC can aid in explaining to military activities and DoD contractors the performance characteristics and merits of such products. This will spread confidence and speed the adoption of qualified products.

The best drawing materials and the best processing techniques will never produce a high quality drawing copy if the original is not drawn properly. Careless drawing preparation techniques, or improper drawing renditions, will result in inferior and unsatisfactory copies.

It is the human skill factor we are dealing with principally in drafting. This variance in performance is missing when standard machine processing is involved. Modern electronic business machines in the field of banking, for example, now read a special set of language symbols to sort, list, and post checks automatically. Here the ability of the machine to recognize the symbols depends on the quality and strength of a magnetic ink used for the image.

If human operators could be machine-consistant, our drawing readability problems would be considerably lessened. That is, provided good standards had been established and were adhered to by all draftsmen.

Recognizing that drafting is a form of art, coupled with engineering know-how, our approach to obtaining better drawing copies lies in the direction of closer cooperation with the draftsmen. What, then, can be done? My suggestion would be: (1) Establish workable standards; (2) Train and indoctrinate draftsmen; (3) Improve cooperation between drafting and reproduction departments, and between drafting and various users of the drawings.

Ways in which the NABDC could foster improvements include: (1) Advertising of an institutional nature; (2) Articles, guides, handbooks, standards, etc.; (3) Seminars, courses, displays, roundtables; (4) Individual contacts by company members; (5) A planned program in cooperation with government and industry.

The Department of Defense is becoming increasingly aware that good drawing management, or more broadly, engineering data management, is fundamental to providing adequate support to our weapons systems. The day is gone forever wherein individual military activities or their respective contractors could operate more or less autonomously under locally devised procedures. For one thing, the pace of weapons development and production has quickened considerably, now taking less than half the total time to reach the operational stage.

The large number of activities involved in any modern weapon system makes it imperative that close integration be achieved among and between those activities. This means the rapid interchange of data; it means fast, efficient reproduction methods to match needs for many copies.

This means that with the increased tempo of military operations, with more activities involved, and larger volumes of data to process, it becomes very important to give guidance to contractors respecting documentation requirements.

My personal opinion is that every activity procuring drawings and associated engineering data on a recurring basis and in sizable volume should maintain a staff of qualified technical personnel to indoctrinate, monitor, audit, and review the technical documentation required under contracts. Contractors should be alerted to the importance of preparing quality documentation.

The Bureau of Naval Weapons has realized the necessity of making certain that the drawings and other documentation purchased by the Bureau will meet the minimum quality standards as prescribed in Military Standards and Specifications. To meet this need a Technical Documentation Group of the Bureau of Naval Weapons is established with the following duties:

(a) INDOCTRINATION—Provides instruction to contractors or government military facilities to delineate what is required under the terms of specific complex contracts with relation to type and kind of technical documentation of a mechanical engineering nature. The instruction is accomplished by formal or informal presentations, defining and interpreting engineering drawings, inspection documents, diagrams, engineering standards, specifications and other applicable documents invoked by contract, to personnel of cognizant engineering facilities.

(b) MONITORING—Conducts in-process checks at contractor's facilities and reviews methods used for preparation of required documents to assure that complex contract requirements have been complied with. This check consists of a review of drawings, lists of drawings, specifications, inspection documents, pamphlets, manufacturing data, diagrams, repair parts lists, etc., pertaining to the mechanical engineering aspects of the documentation, to determine if the essential information is provided to procure, manufacture, inspect, test, maintain

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This article is based on an address by the author at the Eastern Region Meeting of National Association of Blue Print & Diazotype Coaters, Inc., Claridge Hotel, Atlantic City, N. J., May 6, 1961.

store, and use this item. Verbal or written reports are submitted concerning the results of the monitoring to the Bureau of Naval Weapons. This phase is conducted on a continuous basis until completion of the contract.

(c) AUDIT AND REVIEW—Conducts audits and reviews of contractor's or government military facilities, completed drawings and lists of drawings of a mechanical engineering nature to assure that complex contract requirements have been complied with. This audit and review also determines if essential information is provided to procure, manufacture, inspect, test, maintain, store, and use the items described on the documents. At completion of each review, a written report is submitted to the Bureau of Naval Weapons. This report consists of findings and recommendations to approve or reject the work as being adequate.

(To be continued next month)

Defense Standardization Program Publications

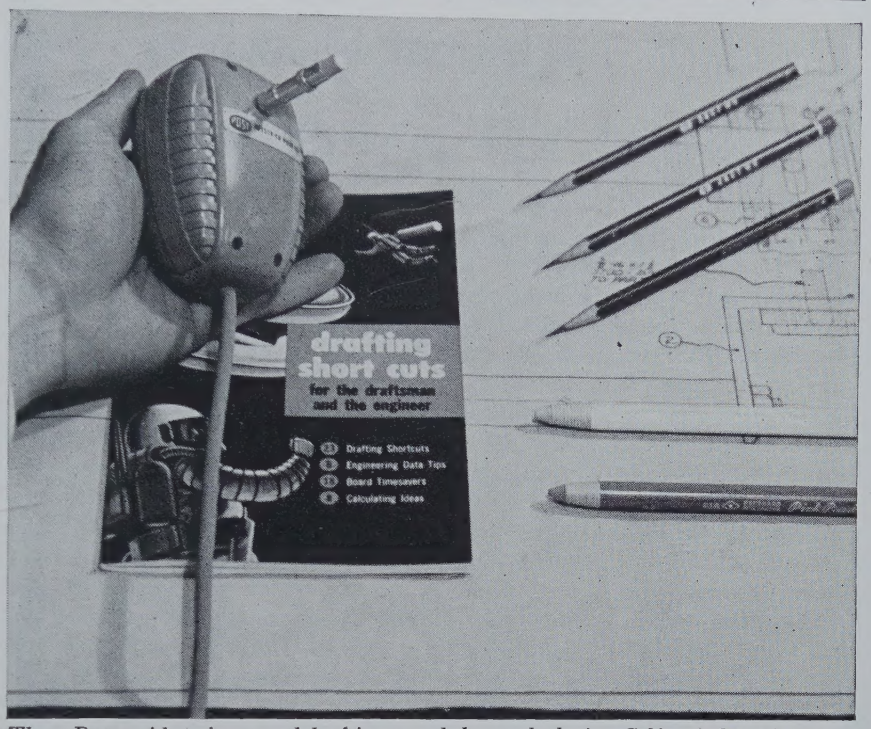
Orders for the Defense Standardization publications of the Standardization Division, Armed Forces Supply Support Center, which are for sale, should be sent direct to the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Remittance should be made payable to the Superintendent of Documents.

Defense Standardization Manual M200

Manual M200 is on sale on a subscription basis. The subscription rate is $6.00 domestic, $2.00 additional for foreign mailing. This scubscription service includes:

Standardization Policies, Pocedure and Instructions; Chapter I—Glossary; Chapter II—Policies and Procedures for Standardization Documents; Chapter III—Studies and Working Groups; Chapter IV—Qualified Products Lists; Chapter V—in preparation—Military Outline of Form and Instructions for the Preparation of Specifications—(Current Issue M205, Military Outline of Form and Instructions for the Preparation of Specifications, 35¢); Chapter VI—Outline of Form and Instructions for preparation of Standards, Standardization Studies and Handbooks.

DRAFTING TRENDS



Three POST aids to increased drafting speed shown clockwise: Self-switching Mercury electric eraser; Triangular-shaped Try-Rex drawing pencils; Peel-off eraser sticks.

New drafting conveniences increase efficiency

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Furnished with an assortment of eraser tips suitable for fast, smooth removal of soft or hard pencil lines, typewritten material, even printing. Accurately erases a one-letter typing error, yet speedily removes large areas of an engineering tracing. Palm-fitting, easy to handle. Durable plastic housing with non-slip finger grips makes erasing a pleasure instead of a chore. The low, $16.50 price is quickly paid for in time and trouble saved.

Try-Rex Drawing Pencils—Embodying the first new pencil design in years, a rounded, triangular casing, the Damascus Try-Rex pencil provides more than a relaxed and comfortable grip. Its three flat sides not only fit the controlling three fingers, but indicate to the draftsman a succession of 120° stops which help position the pencil for uniform line weight and density. Precise grading of lead hardness, plus color-tip coding, further aid production of better tracings and clearer prints.

Pencil-Style Eraser—An eraser capable of hairline control often saves re-drawing of fine detail in small-scale work. For such precise work, there's nothing better than a POST 2934 Pink Pearl eraser, now available in peel-off, self-sharpening pencil style. The POST 2933 Magic-Rub is also a paper-wrapped, peel-off type, but provides a white vinyl tip for clean erasing of drafting film. Both give real convenience when exacting erasure is needed.

Further information on all of these worthwhile POST drafting aids is available from your nearest POST dealer. Or, write Frederick Post Company, 3656 North Avondale Avenue, Chicago 18, Illinois.

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Types of Technical Drawings

by Franz Maria Feldhaus

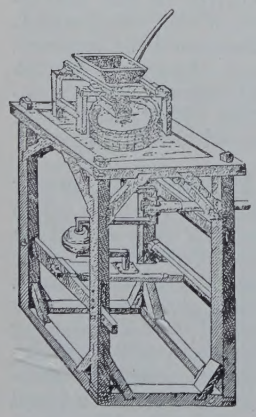
This is a continuation of Chapter III of an authoritative and beautiful book, **THE HISTORY OF TECHNICAL DRAWING**, by Franz Maria Feldhaus published in 1959 by Franz Kuhlmann, K.G., of Wilhelmshaven, Germany, as **GESCHICHTE DES TECHNISCHEN ZEICHNENS**. We are indebted to the publisher for the translation, as well as for permission to republish this fascinating work. It will be continued in this department from month to month, until completed.—The Editors.

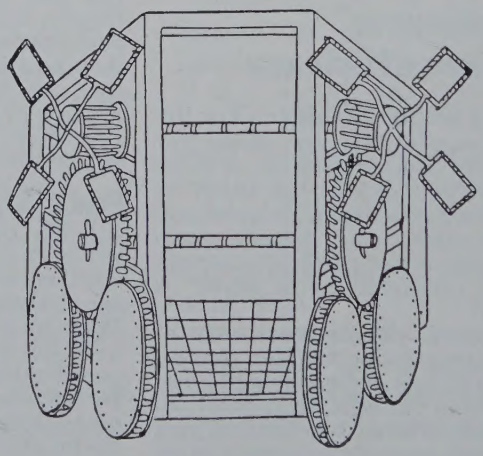
WE KNOW of one case where the author of a manuscript was also an outstanding painter. In art history he is called Master of the Cabinet of Amsterdam. His manuscript has the quite common title *Housebook of the Middle Ages*. It is in the possession of the family von Waldburg-Wolfegg of the castle of the same name in Wurttemberg. This manuscript, published at the earliest in 1476 in the south of Germany, shows in two pictures the interior of a silver foundry. On other pages are found lifting gear, demolition equipment, devices for screw cutting, bridges, mills, bellows, pumps, and rams. Pictures of mining and forging and of monetary systems are also represented.

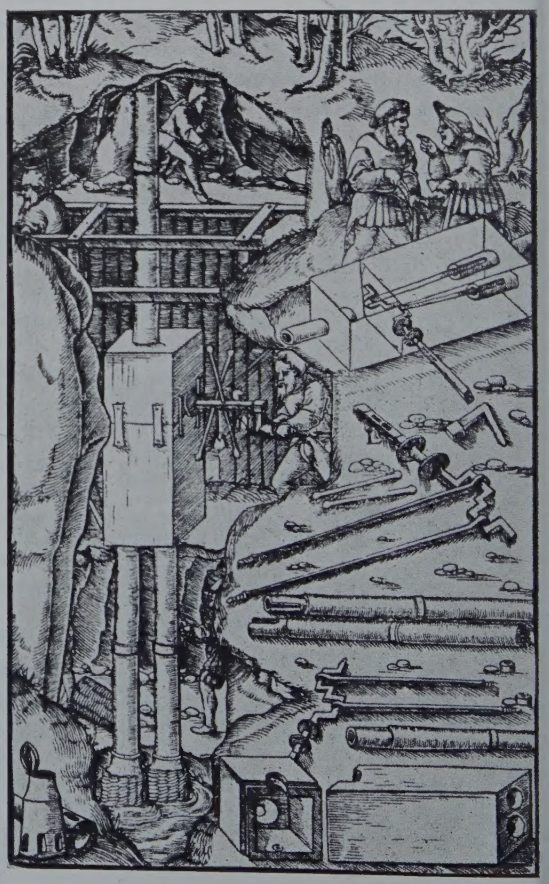
The drawings in this manuscript are perspectively quite good. Mills are so precise in their detail that a mill builder could work from the drawing. Here an artist sees the details of a machine correctly: the doubly set-off metal axle with built-in centrifugal ball and connection rod, the mortise joins of the wood, the metal fittings of the bearings, and the positions of the so-called helpers with which the distance of the millstones from each other is regulated.

The most exclusive of the remaining illuminated manuscripts was written in 1500 by the Knight Ludwig von Eybe. It contains 648 pages of large pictures partly drawn and partly colored, representing war equipment, bridges, screw cutting tools, lifting gear, rams, drills, coin foundries, cable railways, mills, pumps, and other machinery.

Typography, established by Johannes Gutenberg of Mainz and used for small prints in 1446, did not immediately take the place of handwritten documents. Technical books were printed later. The first of these, in 1472, was the work of the Italian Roberto Valturio, whose manuscripts had already been known since 1460. It contains large woodcuts of ma-







MILL (left)
From the Mittelalterlichen Hausbuch, circa 1480

ARMORED WAGON WITH WINDWHEEL DRIVE (center)
Roberto Valturio, Verona, 1472

MACHINE DRAWING (right)
Woodcut by Georg Agricola, 1556

chines, drawn in clumsy perspective. Thirty-six of these illustrations of machines were added by the printer Ludwig Hohenwang of Augsburg, to the printed edition by Flavius Vegetius Renatus of a book on Roman warfare around 385. Progress was so slow at the time that a book remained readable for more than 1000 years. To make it more palatable, Hohenwang added the machine drawings of Valturio although they had no connection with the text. Only after 1500 were small books printed about smelting and mining, but their illustrations, if any, were poor. The earliest illustrated text book on metal was published in 1540 by the Italian Vanuccio Biringuccio.

Sixteen years later, in 1556, the first large illustrated work appeared. It was by Dr. Georg Agricola *De Re Metallica*, twelve essays on mining. It contained 292 exceptionally well drawn pictures of machines containing only a very few minor mistakes. The illustrations are in good perspective and easy to understand even without long explanations.

Illustrated is such a drawing. It represents a two barrelled suction-and-pressure pump which works underground. The drawing is original in that Agricola put the machine directly into the landscape. He opened the ground up in such a way that one can see how the pump works. He drew, so to speak, sectionally. This idea did not go as far as to use sectional drawing of the actual subject of the drawing. The pump is dismantled into single parts and groups of parts. Especially interesting is the transparency of the pump housing thus showing the inside.

This method of representation is the forerunner of section drawing as used today. The inclusion of people and parts of landscapes is not merely ornamental, but also for elucidation. One sees for instance that the pump is operated manually. Small mistakes, like the wrong angle of the crank, are quite rare. We see two metal rods with metal pendulum weights that are fitted to the axle of the crank instead of to a fly wheel. Below, at the right edge of the picture one recognizes two leather washers that seal the pump housing where the axle enters it.

To Be Continued

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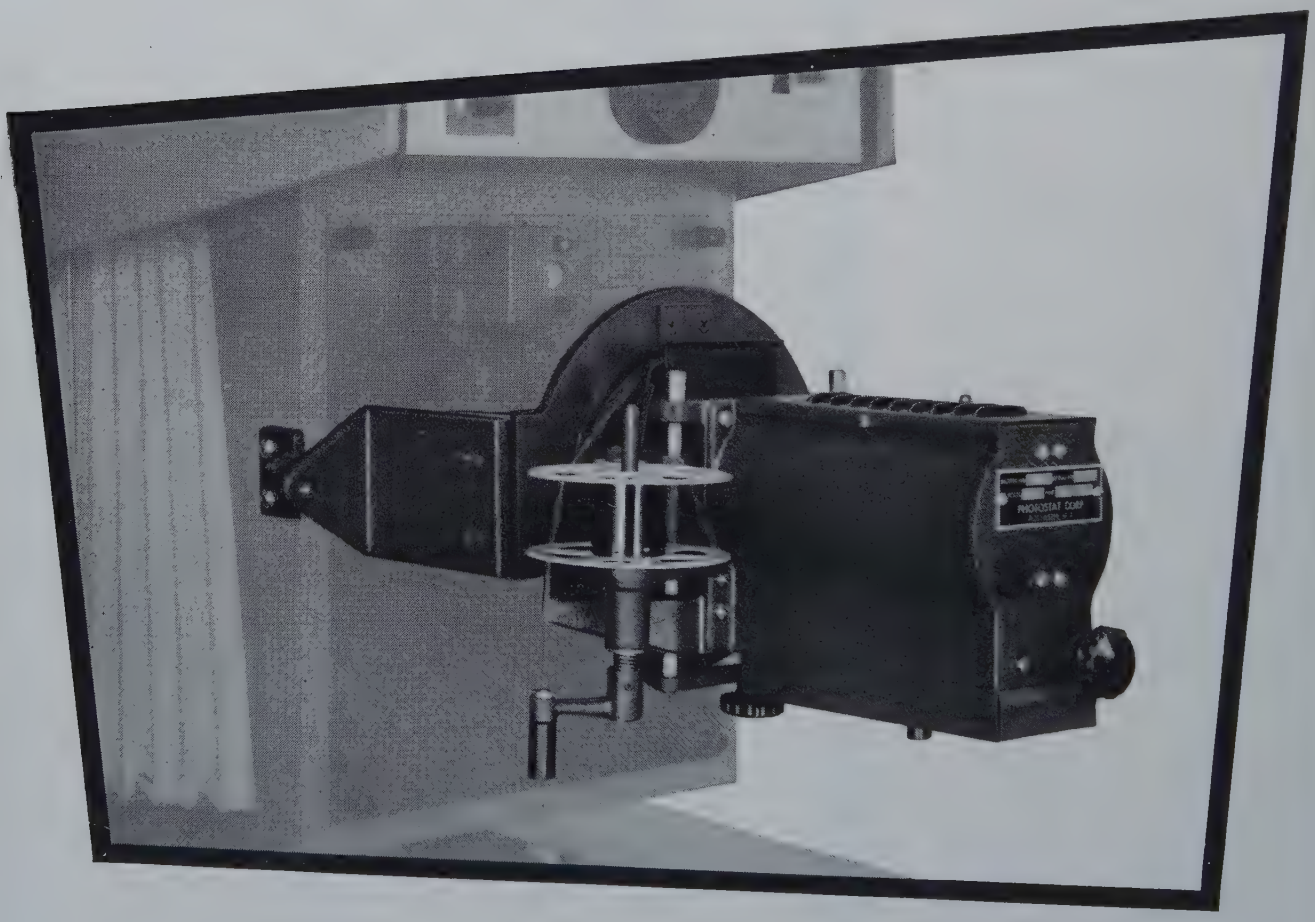

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GRAPHIC SCIENCE

JUNE, 1961

VOLUME 3 NUMBER 6

AMERICAN AND BRITISH PROJECTION

An unfortunate ambiguity can occur as the result of first angle projection which leads to parts being manufactured laterally reversed or even turned upside down

by the late Guy L. Murray

ALTHOUGH architectural working drawings have existed for over four thousand years in the form shown in Fig. 1, it was not until the end of the 18th century that serious attempts were made to represent solid objects of three dimensions on a flat sheet of drawing paper.

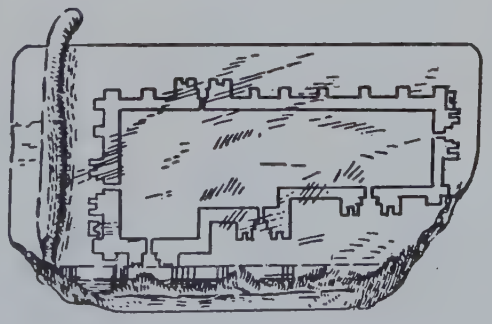
The eminent French mathematician, Gaspard Monge (1746-1818), about the year 1795 propounded his method of projecting the outline of an object on two planes of reference, one horizontal and the other vertical. He made use of what is now known as the First Angle of intersection of these planes, which method is now called British projection. Unfortunately, this angle can cause misunderstandings in workshops which may result in work being made "wrong-handed," or even upside down on occasion. It is a fact that many details reach the scrap heap, and time and money are wasted, simply because artisans and others have not been quite sure which way the draftsman was looking when he placed the views on his sheet of drawing paper.

Attempts are sometimes made to cover up the ambiguity of First Angle projection by placing notes or directional arrows on the various views to instruct the user which way to look in order to read the drawing correctly, but such procedure is surely an admission of the shortcomings of the First Angle method.

This article was written at the suggestion of Frank Woodhead, Chairman of Toledo Woodhead Springs Limited, Sheffield, England.

Headless statue of Gudea in the Museum of the Louvre, Paris.

Gudea was an engineer and the governor of the city-state of Lagash in the country known later as Babylonia. Probably his greatest work was the temple of Ningirsu, a drawing of which is shown on the stone tablet on his knees. An enlarged view of this drawing is shown below and it is interesting to note the graduated scale—about 10¾ inches long—which appears on the edge of the tablet. This is the oldest authentic measure known. The inscription on the skirt on the statue gives particulars of the design, building, and dedication of the temple of Ningirsu.



THE EARLIEST KNOWN "WORKING DRAWING" about 2400 B.C.

Fig. 1

Monge's angle of projection was used in the United States until about sixty years ago when American engineers abandoned his angle because experience convinced them that confusion and expensive mistakes could result from its use. They therefore decided to make use of the Third Angle of intersection of the two planes of reference, which method is now known as American projection. With the Third Angle method every view on the drawing is adjacent to the surface it represents and the draftsman's intentions are beyond dispute. Even so, it needed a bold decision to adopt this new procedure in America, but the results have proved the wisdom of their choice.

In this connection it is interesting to note that in 1922 an admirable book on machine construction and drawings was published in England under the joint authorship of H. E. Merritt and Maurice Platt, and in this volume the authors made use of Third Angle projection. They were severely criticized at the time, but subsequent events have proved how right they were.

In the present state of world affairs there is no need to emphasize the necessity for full collaboration among peace-loving nations on matters of national safety. Indeed it is no exaggeration to say that our future security may depend to a large extent on how far engineering products of Western Europe and America are interchangeable, and this can be greatly assisted by a common system for all working drawings. The importance of such interchangeability is recognized in the recent specification of the British Standard Institution for Screw Threads and in the recommendations in B.S.I. No. 308, for Engineering Drawing Office Practice, which now includes Third Angle (American) projection. Furthermore, the Royal Navy, the British Army, and the Royal Air Force have now gone over entirely to American layout for workshop drawings, and many important branches of the engineering industry are using this method and others are in process of changing over. Clearly, it is only a matter of time before the Third Angle (American) method become established practice throughout British workshops. But unless this change-over is effected speedily and efficiently, draftsmen, artisans, and even executives who move from one works to another will be severely handicapped and perplexed, and costly mistakes and serious delays in production will result.

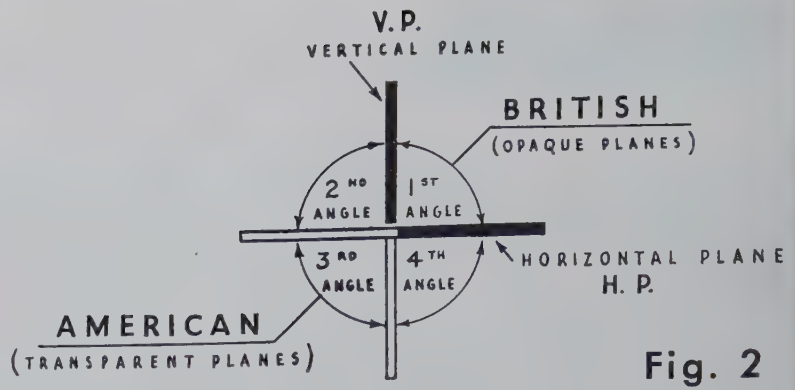


Fig. 2

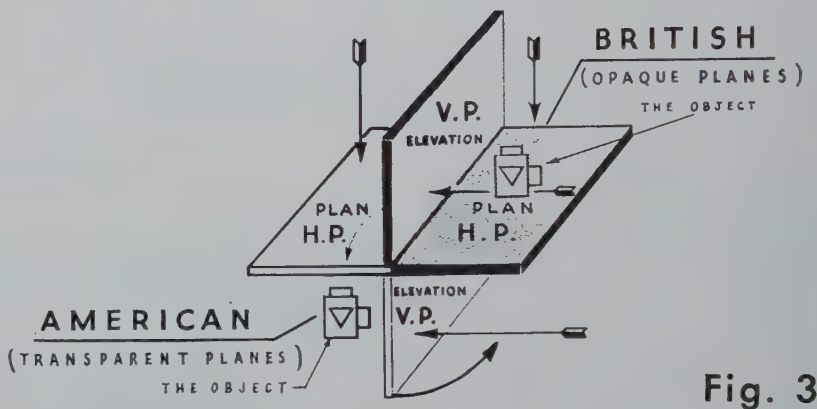


Fig. 3

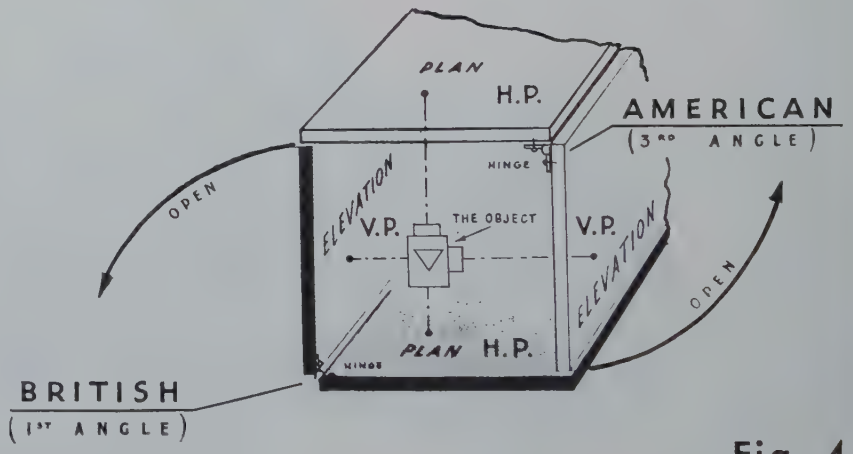
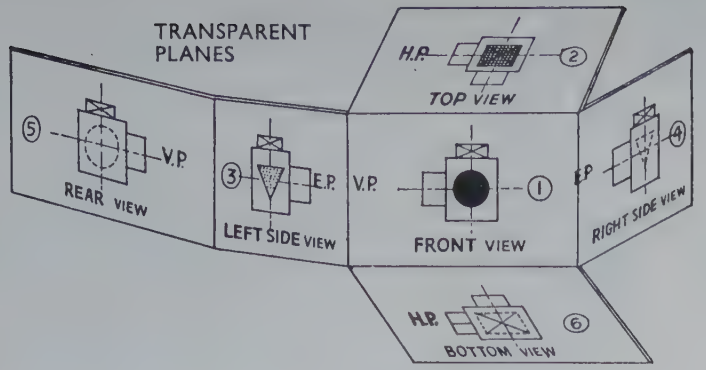


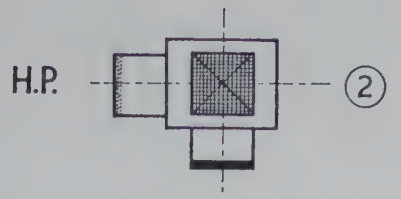
Fig. 4

A proper understanding of the two systems is essential to all those who are concerned with workshop drawings. I will attempt to explain in simple language the basic principle of American and British projection.

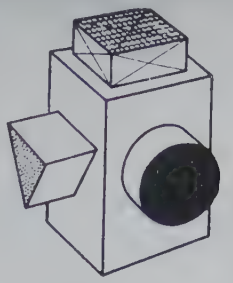
Gaspard Monge was a brilliant mathematician and a life-long friend of Bonaparte, and he acquired great fame as Professor of Descriptive Geometry at the Ecole Polytechnique in Paris. Napoleon had great confidence in him, and in order to speed up the production of armament assigned to him the task of devising a suitable method for showing solid objects of three dimensions on a working drawing.

In 1795 Monge conceived the idea of projecting the various views of the object onto vertical and horizontal planes set at right angles to each other, which planes could then be opened out flat like a sheet of draw-

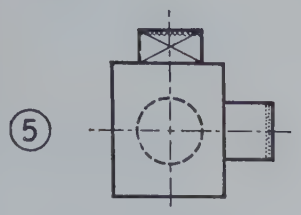




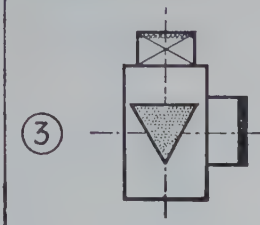
TOP VIEW



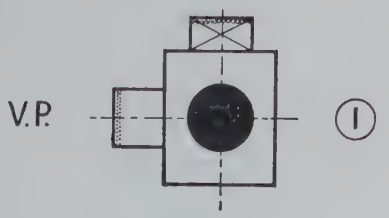
THE OBJECT



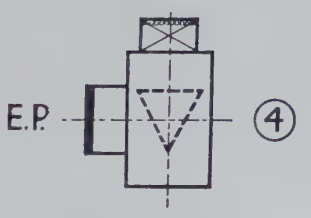
REAR VIEW



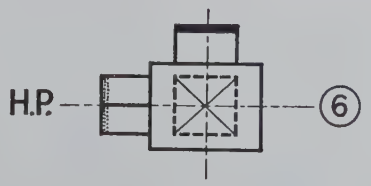
LEFT SIDE VIEW



FRONT VIEW



RIGHT SIDE VIEW



BOTTOM VIEW

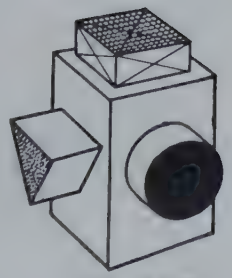
It will be seen from this drawing that every view appears on the sheet of paper in exactly the *same* position that the face concerned occupies on the actual object, i.e., the *top* of the object appears at the *top* of the drawing, and the *left* of the object shows at the *left* of the drawing.
This is stated as follows in British Standards specification No. 308 for **"American (3rd Angle) Projection :—"** Each view is so placed that it represents the side of the object *near* to it in the adjacent view."

— H.P. HORIZONTAL PLANES FOR "PLANS"

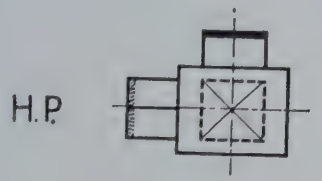
— V.P. VERTICAL PLANES FOR "ELEVATIONS"

— E.P. END PLANES FOR "END VIEWS"

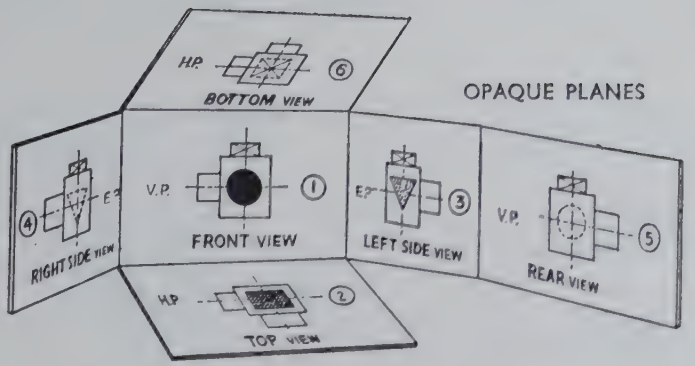
AMERICAN (3rd ANGLE) PROJECTION

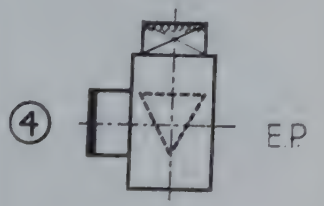


THE OBJECT

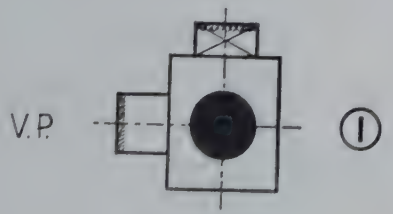


BOTTOM VIEW

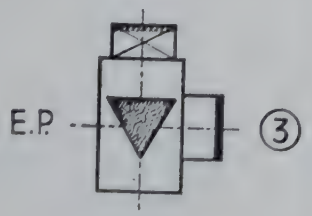




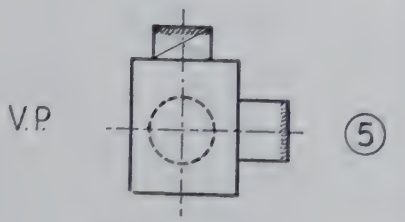
RIGHT SIDE VIEW



FRONT VIEW



LEFT SIDE VIEW

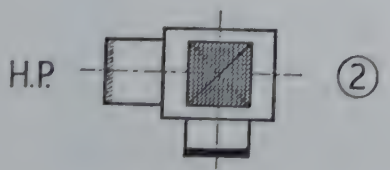


REAR VIEW

— H.P. HORIZONTAL PLANES FOR "PLANS"

— V.P. VERTICAL PLANES FOR "ELEVATIONS"

— E.P. END PLANES FOR "END VIEWS"



TOP VIEW

It will be seen from this drawing that every view appears on the sheet of paper in the *opposite* position to what the face concerned occupies on the actual object, i.e., the *top* of the object appears on the *bottom* of the drawing, and *left* face shows on the *right* of the drawing.
This is stated as follows in British Standards Specification No. 308, for "**BRITISH (1st Angle) Projection**:—Each view is so placed that it represents the side of the object *remote* from it in the adjacent view."

BRITISH (1st ANGLE) PROJECTION

ing paper (Fig. 2). As stated earlier, Monge made use of the First Angle of intersection of the two planes, and for about a hundred years this method was accepted as standard practice by engineers of all nations.

It will be seen from Fig. 3 that the two planes shown in Fig. 2 are considered to be of unlimited length and that there are four possible intersecting angles which are numbered 1, 2, 3 and 4 in Fig. 2. These angles are sometimes referred to as the four dihedral angles. It should be understood that when viewing an object placed in any one of these angles of vision, called the projectors, they are always at right angles to the surface of the two planes concerned, or in other words, the user must always look in either a horizontal or vertical direction as indicated by the arrows in Fig. 3.

Now let us consider what happens if an object is placed in the First angle in Fig. 3. If an elevation is required, the viewer looks at the front of the object and the horizontal lines of vision are projected onto the vertical plane which is at the back of the object. Similarly, if a plan is required the viewer looks down on the top of the object, and the plan is projected onto the horizontal plane, which is below the object.

From this it will be appreciated that with First Angle (British) projection the planes are always behind the object to be viewed and for practical purposes are considered to be opaque, and it therefore follows that the views are always remote from the surface of the object viewed.

Now consider the same object placed in the Third Angle as shown in Fig. 3. The directions in which the object is viewed are exactly as stated before, but it will be observed that the two planes now come between the viewer and the object, and to see the object, the horizontal and vertical planes must now be made of transparent material. This method of projection has many practical advantages, for if a plan of the object is required, it is viewed vertically at the top and the resulting view also appears at the top of the drawing. Similarly, for a front elevation, the front of the object is viewed horizontally, and the resulting view is also at the front. From this it follows that in the Third Angle (American) projection the user is left in no doubt regarding the particular surface of the object represented in each view, because every view on the drawing shows the surface which is next to it in the adjacent view of the object.

It is hoped that the foregoing remarks will help all those who are associated with drawing offices, technical colleges, and workshops to understand the difference between American and British methods of projection, and equally important, where the various views of any object should appear on a working drawing under both systems.

There is no doubt that for practical purposes the American method of projection has many advantages, and once the principles are properly understood, it is safer to use than the British method because it eliminates the possibility of errors. Moreover, experience has proved that with proper explanation the change-over from First Angle to Third Angle methods is comparatively easy.

MAP DRAFTING AND REPRODUCTION

A description of the mapmaking techniques of Rand McNally with a history of the development of the mapmaker's art

by Arthur L. DuBois

Since long before Columbus launched the tourist trade in the Bahamas by charting the first ocean cruise route to Watling Island, maps have played a key part in the advance of civilization. Explorers and travelers both before and since Columbus have found it necessary to add diagrams to make their storytelling complete. Even in their earliest forms, these diagrams were really pictorial representations of the earth's surface—and our first maps.

By the time Columbus sailed in the late 15th century, mapmaking had become fairly accurate and scientific. In fact, Christopher's brother, Bartholomew, was a well known chartmaker in Lisbon and instructed Columbus in mapmaking and navigation. And luckily, too, for although Columbus' story of his voyage made good listening, Queen Isabella would have been less than pleased without his maps locating the lands he had claimed in her name and showing how to get to them.

Although today there are still large areas of the earth's surface that have not been mapped in precise detail, their exploration is more apt to fall to the scientist and to the jet pilot with his automatic cameras than to the seafaring adventurer. And mapmaking depends not so much on the scientist-mathematician and the explorer as on the technical skill and knowledge of a wide range of highly trained specialists—not the least among them being the draftsman-cartographer.

It is the draftsman who actually physically draws a map in its final stages. And if his craft is essentially mechanical, it is as important and demanding as any of the other skills that go into making a map.

MOUNTAINS: An artist draws the mountain relief with an airbrush spray.

Where Mapmaking Begins

For a commercial mapmaker such as Rand McNally, a map begins with a customer who has a need for a map that will do certain things. The customer may be an oil company requiring a state road map or one of Rand McNally's own publishing divisions seeking a series of terrain and political maps for an atlas or textbook. Whatever the customer's needs, they are woven into a set of precise specifications that state clearly what the objective is in creating the map and what theme will predominate.

If the map is to be incorporated in the passenger's flight folder on a commercial airline, the main theme will most likely revolve around depiction of mountain ranges and airport facilities. These are the two things researchers have found airline passengers want most to see on a map. Or perhaps a college textbook publisher requires a map showing the economy of one of the states—say Washington—telling how its inhabitants earn their livelihoods. In the moist western portion of that state, the economy is based on dairy farming, lumbering, and fishing. In the drier Inland Empire of the eastern portion of the state, fruit and wheat farming are of great importance. Dividing the two areas are the glaciated peaks of the Cascade Range. The sea dominates the coastal economy. These are the map's thematic elements which the draftsman will eventually pictorialize with lines and symbols.

Getting the Facts

Once the map specifications are established jointly by the customer and mapmaker, then it is up to the cartographic research specialists—expert geographers trained also in the specialized requirements of mapmaking—to determine what the facts are concerning the area to be mapped. Where are the highways, the airline routes, and the mountain ranges and how are the latter shaped? Where do boundaries, rivers, and railroads run? Where are the cities located and how large are they?

All this information is gathered from many sources including aerial photography, survey reports, statistical tables, government charts, and

general geographic reports.

Next, geographers translate this information into a geographic compilation. They initially construct a base map drawn to the specified scale. Then on a series of overlays they add the natural and man-made features that are to be shown. One overlay may show vegetation in green, another highways in red, and a third may portray state or international boundaries in black. When superimposed one over the other, these overlays tell the complete map story.

The Role of the Artist

Now only one step remains before the map reaches the drafting and reproduction stages. The artist must select line weights, type sizes, colors, and layouts and thus determine the map's final appearance. This important function is assigned to the artist because he is trained to visualize the final product and because he can choose type and color schemes which will best emphasize the map theme. The artist will develop colors which highlight important features while subduing less important areas. He will choose type that is legible and yet does not dominate the map, linework sizes that emphasize the map story, and a layout that trains the reader's eye on a central theme.

At this point the map passes from the research to the production phase and the actual map drafting begins. The compilation which is furnished to the map draftsman-cartographer becomes the base from which the new map is to be built. The draftsman-cartographer must accomplish three main tasks: (1) drafting the map linework, (2) placing type on the map, and (3) preparing the map colors. Each of these jobs is, in itself, an interesting story.

Adding Linework

Map line drafting was, until the early 1950's, usually accomplished by pen and ink. By either inking on an overlay placed over the compilation or by inking on a drawing paper onto which a blue image of the compilation had been photographed, the cartographer laboriously drew by hand, in varying line weights, the roads, rails, rivers, coastlines, boundaries, and contours. The end result was a very attractive (and expensive) art drawing that required extensive redrafting each time the map was brought up to date.

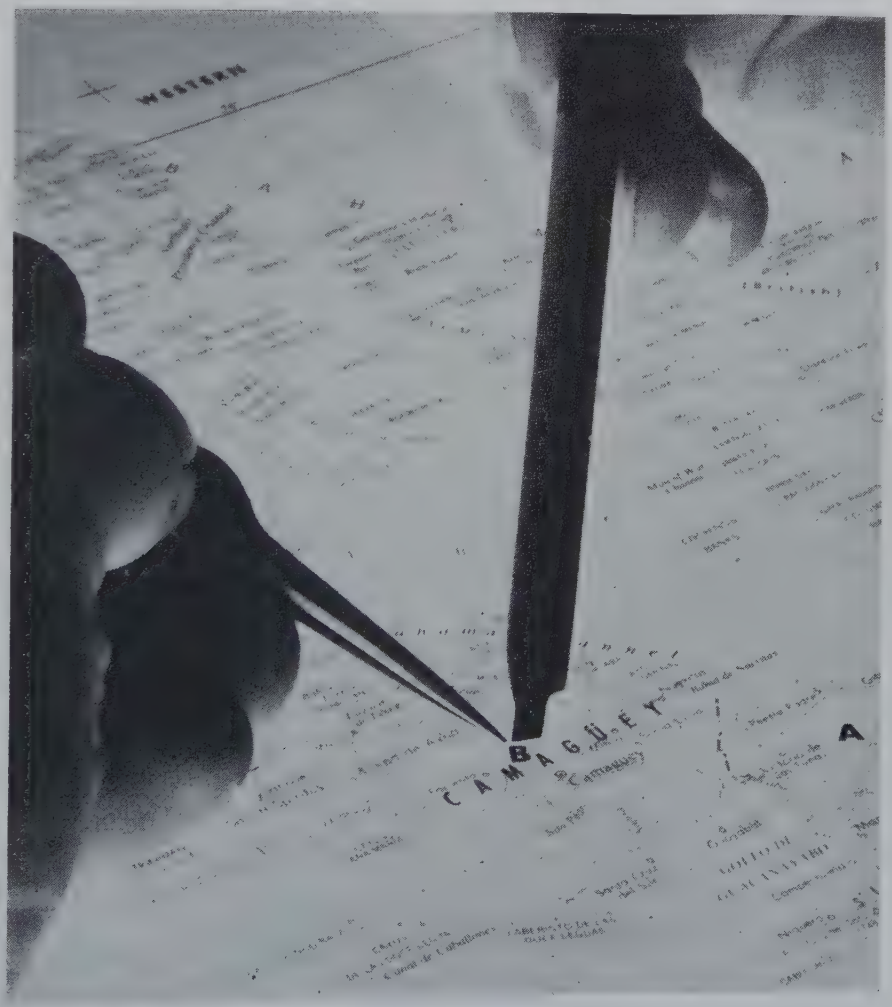
In recent years, however, map drafting has undergone a dramatic revolution which is still continuing. The complex and expensive pen-and-ink process is rapidly being replaced by an entirely new drafting method called scribing.

The advent of the scribing process not only changed the method by which lines were put on maps, but it also changed the entire cost structure in map creation. Today, line work is placed on most maps by the scribing process and only old map drawings which need extending or correcting are prepared by the old method.

A scribe sheet is a dimensionally stable, transparent plastic film which has been coated with an opaque or translucent paint. The addition of a photo-sensitive emulsion and the exposing of the scribe sheet to the geographer's compilation in a contact frame produce a blue line image in the emulsion. By pulling an etching tool across the coated surface of the scribe sheet, following the blue line image, the mapmaker can cut a line into the coating on the plastic—the line that once was drafted by pen and ink. The line may be a superhighway, an airline route, or a state boundary, but it is always created by removing the scribe sheet coating with an etching tool.

All the red lines will be scribed on one sheet, the blue on another, the black on still another. Thus, the map is prepared color-separated and each scribe sheet need only be photo-composed with the other materials which will appear in that particular color (the black, line-work scribe will be composed with the black type, etc.) for reproduction on printing plates.

Scribing offers several important advantages to the mapmaker. First, it insures constant line widths. If the scribe tool is properly handled, even on such finely detailed work as con-



TYPE PLACEMENT: Names are hand-placed across the map. As many as **75 pieces of type per square inch may confront the commercial mapmaker.**

SCRIBING: A draftsman-cartographer scribes the coastline and rivers for an atlas map. Shown here is Cuba and the West Indies.

tour lines, only one width of line can result, since the cutting blade holds the line-work size absolutely constant. The scribing needles or blades are constantly checked and retouched on abrasive stones to insure uniformity. Second, scribing is far faster than pen-and-ink drafting. Third, by scribing line-work colors on separate scribe sheets, the expense of subsequent color separation is avoided and production time reduced again. Camera work is eliminated since each scribe sheet is itself a negative which can be used for final composite positives. Fourth, scribing offers substantial savings in annual map-correction costs since the scribe sheets need only be amended to incorporate changes, a process far less expensive than hand-inking changes.

Adding Type

Placing type across a map is another area which has undergone changes in the past few years. It was not many years ago, for example, that all names were hand lettered upon a map. This highly refined skill has all but disappeared and hot metal forms of typesetting, offering a wide variety of faces, are now the main source of map type. But despite these changes, the most neglected area of cartography is still map typography and type placement. Even hot metal cannot offer the variety of type styles and sizes necessary, and commercial mappers look forward to the time when better methods are available for producing the variety, selection, and economy their maps require.

The process of getting type onto the face of a map is accomplished almost completely by hand. The cartographer - draftsman classifies the names furnished on the map compilation into style and size categories and orders the type from a typesetting shop. Most commercial mapmakers do not have typesetting machines. The type returns as either a printed sheet for use in updating old drawings, or as type on a transparent film backing for use in making scribed maps. An adhesive (usually wax) is applied to the back of the transparent film or printed sheet and each piece of type is individually cut out and placed in position. On scribed maps the transparent type is adhered to overlays, with each type color on a separate overlay. Each overlay is then ready for subsequent contact or camera work.

If there is one distinguishing feature of commercial maps, it is dense type stick-up on small-scale maps. On many commercial maps, and most typically the road map, as many as 75 pieces of type and symbols per square inch confront the map maker. Fifty names and symbols per square inch are commonplace. Most important, the cost of typing a map (including type listing, symbols selection, typesetting, and type-positioning) amounts to between 40 and 50 per cent of original cartographic cost. Although important steps have been taken to mechanize the type stick-up operation, notably foreign-made, semi-automatic type placement machines, the type stick-up process remains essentially hand-done and very costly. It is not uncommon to spend 700 or 800 hours hand-placing type across a single road map.

Adding Colors

The third major mapping phase which the draftsman-cartographer must accomplish is preparing the map for the color scheme it will show. Here again is an area in which important production advances have been made in the past few years. Historically, maps were color separated by opaquing on duplicate negatives. A series of negatives were made of the map drawing and on one negative everything would be opaqued (by hand) except the red colors. On a second negative everything would be opaqued except the yellows. This process would then continue until every color that appeared on the map would have an opaqued negative. Even today, this same process is used by some mapmakers for preparing color separations. It remains the main method of color-separating old map drawings.

Much faster and more efficient, however, is the strip-mask process which has revolutionized the task of achieving color-tinted areas upon a map. Strip-masks are window negatives through which exposures are made in a contact frame in combination with a line screen. Each photo-sensitive strip-mask consists of stable base film covered with an etchable photo-sensitive surface which can be peeled away. By exposing this film to a line-work positive or negative, lines are etched into the photographic emulsion. These lines serve as guides for hand-peeling a window negative. Colors will appear only in hand-peeled openings.

Even on the most detailed maps, such as atlas maps showing contour lines and relief layer tints, the time involved in peeling the series of open window negatives is about half the opaquing time required on an old-style duplicate negative to achieve the same end.

The Final Steps

These, then, are the three main tasks which must be accomplished by the draftsman-cartographer. He has placed the line work, type, and colors upon the map and his

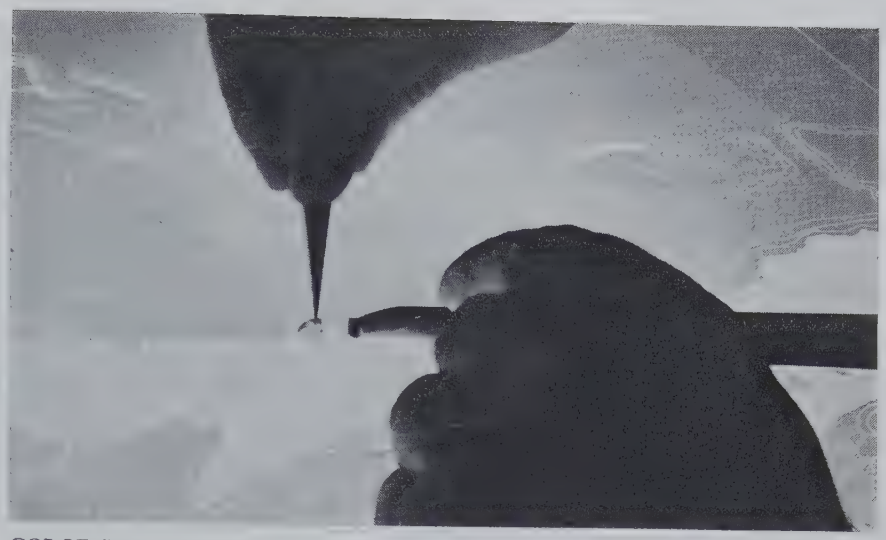
work is almost ready for combining into final positives or negatives for plate-making. First, however, he must add some refinements. A border and index must be developed and fitted to the map. A legend block must be added to explain the cartographic detail, and a myriad of other materials such as titling information, half-tone photographs, explanatory copy, or even process art work may need to be added. Once these materials are positioned, the draftsman-cartographer's work is finished, save for checking and correcting.

Now the modern map enters its final creative stage: composition of all material into final negatives or positives. The length of the printing run will determine whether final composition will be in negative or positive form. Longer runs (over 150,000) will be printed by deep-etched offset plates made from positives, while shorter runs will be printed on albumin offset plates, made from negatives.

Why Offset Printing?

It is important at this point to explain why offset or lithographic printing is used almost exclusively in printing maps. Historically, maps were printed by letterpress, and making new press plates whenever corrections were necessary was a costly process. In 1872, however, Rand McNally adopted the wax-engraving process, a method of making map plates which permitted the insertion of correction patches instead of laboriously lithographing, re-engraving, or etching new maps on stone, steel, or copper. This advance insured map users not only of up-to-date maps, but also of less expensive maps as well. Updating costs still remained high, however. Only after World War II did offset printing for maps replace letterpress. Offset offered the advantage of vastly cheaper correction costs since only film negatives or positives had to be updated, and then a new, less expensive, press plate created. The laborious work of correcting letterpress plates was eliminated.

Today's offset printing plates may be the result of as many as 40 or 50 camera exposures. All of the materials furnished by the draftsman-cartographer must be combined into composite negative or positive form for plate-making. On a four-color road map, for example, all the black will be photo-composed into one final negative or positive. The blues, reds, and yellows will each have individual negatives or positives. Each exposure must be made in perfect register with all others. Special artwork or other material would, of course, require additional exposures.



COLOR TINTS: An open window or Strip-Mask negative is made by pulling away a painted coating. This is one of many new processes being used in modern mapmaking.

Once printing plates are made, the map's creative work is virtually complete. A trial press run, or proofing, will indicate if any final corrections or changes are needed before the printing run begins. At this point final line work, type, and color changes are applied by the draftsman-cartographer and new final positives or negatives and printing plates are made. Often, however, time and expense can be saved by using color-film prints made from final positives or negatives for checking instead of press proofs. This saves the cost of remaking printing plates if revisions are needed. Even after final press plates are made, constant quality examinations are performed by pressroom and cartographic checkers as maps flow through the presses at the rate of 4,500 to 5,000 impressions per hour.

Space Mapping Next?

This basic summary of mapmaking methods has purposely avoided some of the more minute technical details of drafting and reproduction techniques. The focus has been on the essential creative work common to every map. If there are two important facts that should be remembered about mapmaking, they are: (1) good maps are the result of the successful integration of the talents of geographer, artist, cartographer-draftsman, lithographer, and printer; and (2) maps, even with recent production advances, remain essentially the hand-made work of skilled craftsmen.

The days of the all-skilled master cartographer have passed, however. Adam Smith's division of labor has arrived for mapmakers although two centuries late. Only with recent production changes (strip-masks and scribing) have mapmakers been able to set up separate production sections. Now we may look forward to the day when the mapmaking process is better automated, yet still incorporates the individual creative skills of the artist, geographer, cartographer-draftsman, and other specialists. And perhaps, as the space age progresses, adventurers like Columbus will again enter the picture as mapmakers begin to chart the universe for space travelers.

The Author

Arthur L. DuBois is a Production Controller and Cost Analyst in the Cartographic Division of Rand McNally & Company, Chicago. He first entered the mapmaking field while assigned to the Strategic Air Command's Aeronautical Chart Centers. DuBois is a graduate of Colgate University and the Northwestern University Graduate School of Business Administration.

Application of Graphics to Engineering Design Problems

Some challenging examples of how graphics are used in the practical solution of engineering problems

By P. G. Belitsos

CONTROL OF FREE STATE VARIATION

Part I of a Series

FREE STATE VARIATION is a relatively new term in engineering design which describes the variations in the geometric form and positional relationship of the surfaces of light-weight structures which distort in the free state when unsupported by external forces. These non-rigid surfaces may distort because of the relative weight or flexibility of the part or assembly, or because of internal stresses created or released during fabrication.

For many years industry has endeavored to develop methods for specifying the control of form and position for functional surfaces so as to get mechanical structures to fit together properly with their geometric elements having the proper relationship to each other. To express these complex design requirements so that they would have common interpretations by design engineers, manufacturing engineers, inspectors, and suppliers has been a continuing and difficult problem. It has challenged the ingenuity of many companies and industries and has been given considerable attention and study by such technical societies as SAE, ASEE, and ASME. It has gained country-wide attention in the National Standards of the American Standards Association and in the Military Standards of the Department of Defense.

In the Flight Propulsion Division of General Electric we have spent years in the dimensional analysis of engineering designs continuously developing improved means for controlling the geometric forms and positional relationships of individual components and various aircraft engine assemblies. Fig. 1 illustrates a cross-sectional view of an aircraft turbo-jet engine showing the compressor section, combustion and turbine section, and afterburner section which gives you some conception of the types of structures and the assembly relationships with which we are dealing.

Let us focus our attention for a moment on a portion of the compressor section which shows the inlet guide vanes and some of the compressor rotor blades and compressor stator vanes. In cross section these parts appear relatively simple. However, the engineering graphics involved in defining their configuration and maintaining the appropriate axial and radial clearances at assembly are extremely complex. Fig. 2 illustrates a typical compressor rotor blade which represents a very challenging problem in graphics. This involves the definition of a warped airfoil surface resulting from the orientation of each of the airfoil sections about a stacking axis as shown in the plan view. The airfoil itself is then located in relation to its base which is a multi-lobed dovetail that is used to secure it in position on the compressor disk.

There are few parts in the design of aircraft engines—or for that matter in the design of missiles or space vehicles—that require the application of so much of the existing knowledge in engineering graphics and descriptive geometry. And yet the urgent need to cut down the development cycle time for compressors has made it necessary to reduce the design elements of a compressor blade to a series of mathematical formulas and establish a computer program for determining their detail dimensions. More and more attention in industry is being given to programs of this type which more closely relate the graphical and mathematical solutions to engineering design problems. Although I cannot go into the details of the complicated computer program for compressor and turbine blades, I will point out later a more simple application in the design of multi-plane rigid metal tubes.

Considerable progress is being made in programming parts so that they can be produced in machines directed by either magnetic or punched tapes. The direction of the

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This paper was presented at the Summer Conference on Graphics in Scientific Engineering held at the University of Detroit, July 18, 1960, by the National Science Foundation.

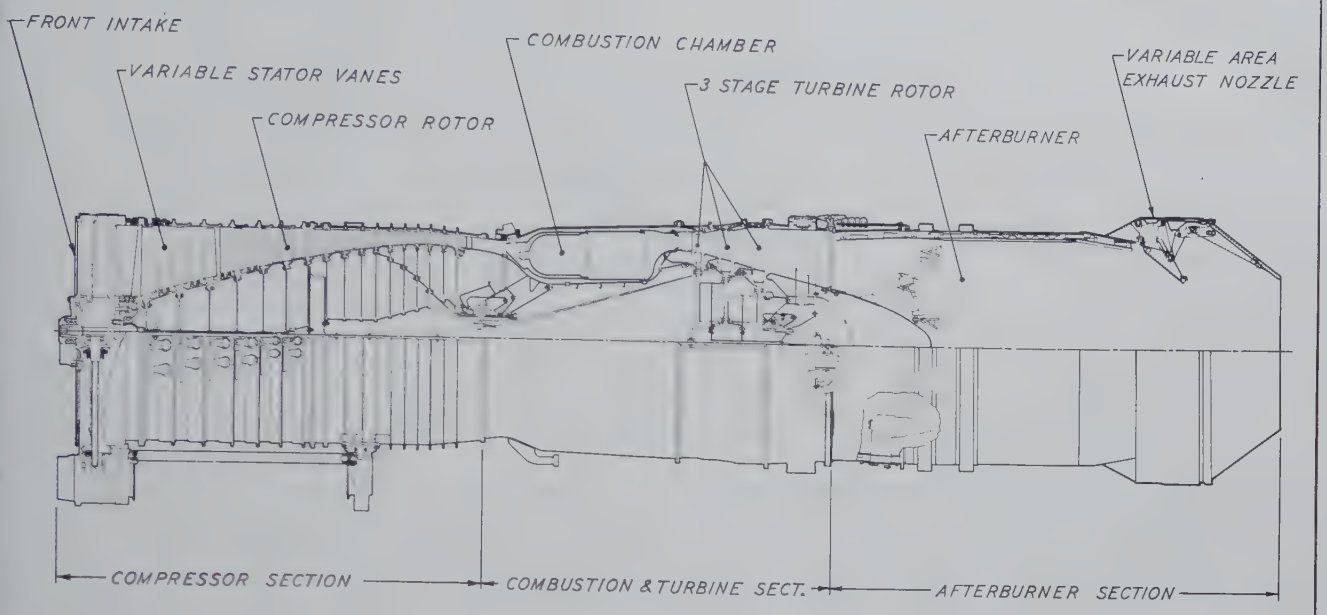

FIG. 1 ENGINE ASSEMBLY DRAWING

cutter path depends on numerical-control computer programs based on engineering dimensional data derived from the drawing involving points, lines, circles, planes, conics, and curves in both two and three dimensions. This is having a significant effect on the graphical representation and dimensional definition of designs on engineering drawings.

To complicate further the control of free state variation and the geometric form and positional relationship of nonrigid surfaces, the operating temperatures and pressures of jet engines have increased rapidly between each successive engine model. In addition, the over-all diameters and lengths of the high thrust engines have increased while the specific weight (ratio of engine weight divided by engine thrust) has had to be reduced to allow for the extremely high operating speeds of advanced aircraft. This combination has created many new engineering problems and challenges. As the engine structures became lighter and more flexible we found that many of them distorted after removal of external forces which were applied in the fixtures used during manufacture. Since these structures were thus no longer rigid in the free state we were faced with the problem of controlling this free state variation and its effect on the geometric form and positional relationship of the various features of each design.

Until this time, the dimensional analysis of parts was based primarily on the assumption that the parts were rigid in the free state. Structures were designed wherever possible so that they did not distort due to their weight or flexibility. Thus to control the geometric form and positional relationships of the elements of a rigid part or structure it was necessary to go through a relatively simple analysis that included the following:

1. Establishment of the functional requirements and operational characteristics of the complete equipment and of each of the parts.
2. Study of the assembled relationships of all the parts that made up the equipment. This included static fits, rotating clearances, alignment requirements, etc.
3. Establishment of the functional datum surfaces and assignment of the geometric form and positional tolerances.

These same steps apply to nonrigid structures except that in addition consideration must be given to controlling the variation of the surfaces which distort in the free state.

After a design has been established and it is determined that one or more surfaces of the resulting part or structure will not be rigid in the free state, it is necessary that the drawing control the amount of distortion that can be tolerated. This can be specified on the drawing by several methods:

1. Use of Liberal Tolerances. In this method the specified tolerances of form or position are made liberal enough to cover expected variations due to the distortion of surfaces in their free state. This method is impractical on surfaces where a considerable amount of distortion is expected.
2. Measuring in Machined Position. In this method the drawing includes a general note that specifies that "all dimensions to be met in machined position." Where this note is specified it indicates that inspection of the part or assembly can be performed while it is in the machined position. This in-

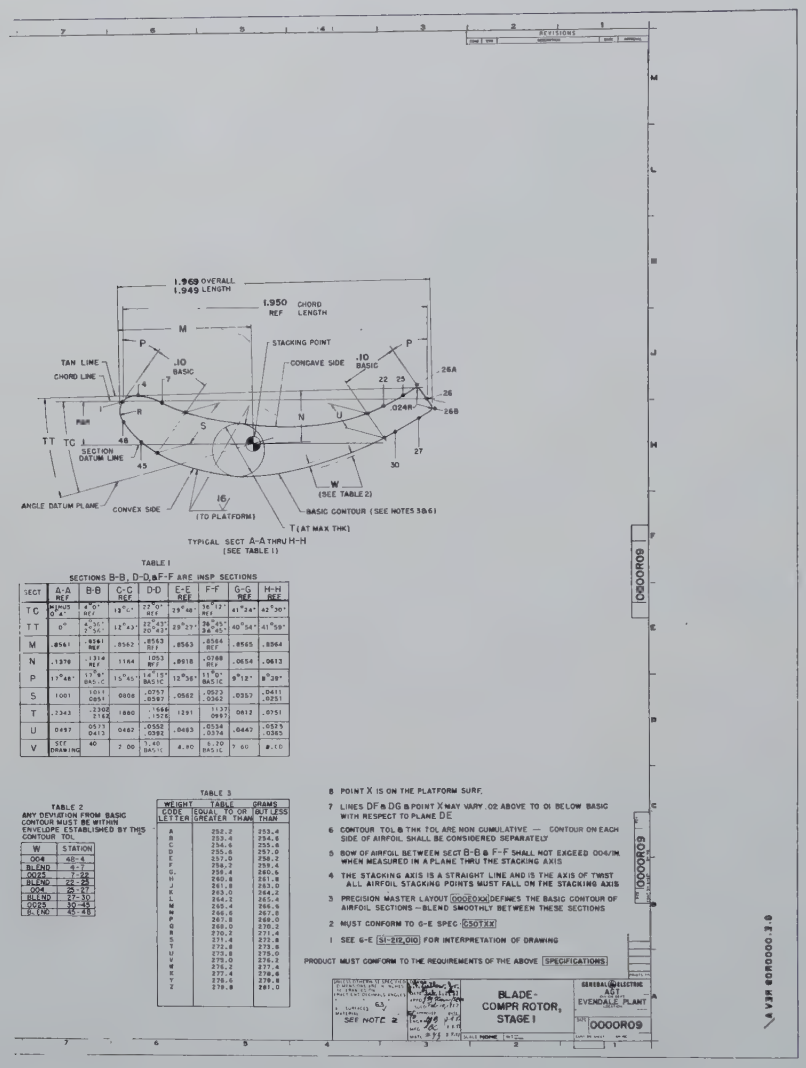

FIG. 2 STAGE I COMPRESSOR BLADE

cludes the nonrigid surfaces that would distort if unsupported by external forces which in this case are exerted by the machining fixture. The use of this note also recognizes the fact that when the part or assembly is removed from the machined position it will not meet the dimensions on the drawing in the free state.

This method should be used only where parts are made and inspected locally, not where parts are made by many suppliers in widely separate locations. Where this note has been used in these cases it has resulted in a number of disputes when the resulting fabricated structure could not be assembled in the application where it was designed to be used. The design contractor would claim that the parts were defective and the supplier would claim that they met the print when they were inspected in the machined position.

The use of this note does not in any way control the allowable or expected maximum out-of-roundness or the variations from true shape in the free state condition. Therefore, when parts do not fit at assembly it is difficult to determine if they have distorted beyond expected limits or have been permanently deformed by damage at the supplier's plant or during shipment. As a result the following method was developed:

3. Restraint While Measuring. In this method the drawing specifies that the part is to be evaluated after it is restored to the geometry that it will assume when it is assembled in its intended application. The requirements specified are carefully chosen to accomplish this so that no greater forces will be exerted than those which will be exerted at the final assembly of the part. This method has been used with considerable success.

After a design has been reviewed and it is determined that the resulting part or structure will not be rigid in the free state, the amount of free state variation is limited as required in the following manner:

1. Select and identify the locating features of the part which are to be used as the datum surfaces.
2. Determine and specify the amount of the restraining and holding forces necessary to simulate assembly conditions.
3. Specify on the drawing that when these features of the part are restrained to the specified conditions, the remainder of the part or certain of its features must be within the specified tolerances.
4. Include in the restraining note the phrase "may vary from true shape" as an option so if dimensions are met in the free state, it will not be necessary to restrain the part.

Selection of Datum Surfaces

The selection of proper datum surfaces which is the first of the above steps is very important in engineering design. This is particularly true in those designs involving control of free state variation because these datums control the relative position and movement of the mating parts of an assembly. They also control the accumulation of tolerances as well as establish the basis for measurement. They should be selected primarily on the basis of functional requirements with consideration for the needs of manufacturing, inspection, and assembly.

In controlling the relative position of components at assembly, it is necessary for the designer to apply a working knowledge of some of the

principles of analytics, kinematics, and the mechanical functions of datums, and datum systems. For example, in order to restrain any component relative to another so that it has no degree of freedom or only certain degrees of freedom, it is necessary to restrict the movements of translation or rotation about or along the coordinate axes. To illustrate this the rectangular body in Fig. 3 is moved to point 0 which is the intersecting point of the three mutually perpendicular axes OX, OY, and OZ. This body may move along any one of these three axes without rotating, which illustrates the three different translational movements available to it if it is unrestrained. Similarly the same body may rotate about the axes OX, OY, or OZ without moving along any of the axes and therefore has three different rotational movements available if it is unrestrained. The three translational and rotational movements make up the six degrees of freedom available to any body.

Economical designs can be developed by using suitable datum systems incorporating the minimum number of locating features to achieve the desired restraints on the relative movements of mating components. Thus with the need for positional accuracy restricted to a few features, all remaining features become relatively unimportant and can be given larger minimum clearances and correspondingly larger positional tolerances.

Datum Features and Datum Systems

Datum features may be points, lines, or planes that are used to establish a fixed framework with respect to which other features are located with toleranced dimensions. In general, datums or datum systems fall into one of the following categories:

1. Three Coordinate Planes. The simplest complete datum system is one which makes use of three planes which are mutually perpendicular such as the three adjacent surfaces at the corner of a rectangular solid. These three planes represent in practice the theoretical coordinate planes of the geometric reference frame, and all other positional features are measured or gaged with respect to these planes.

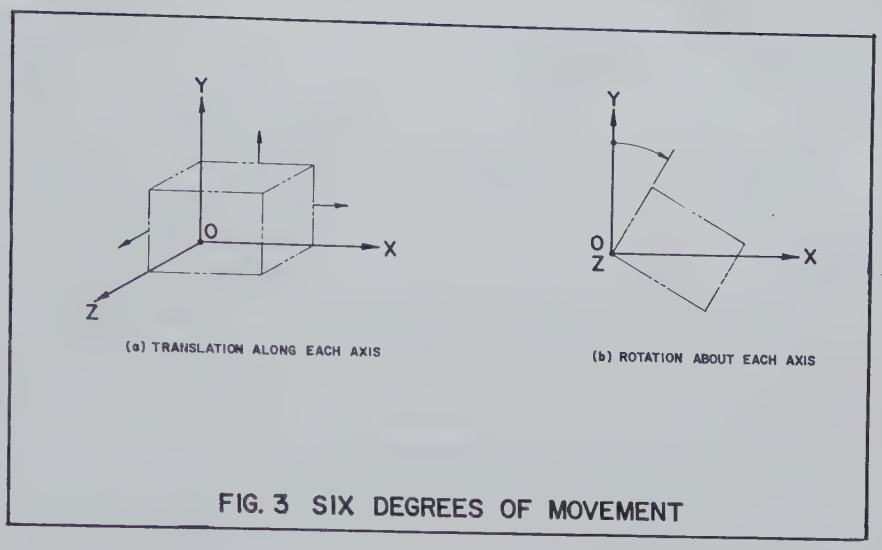

FIG. 3 SIX DEGREES OF MOVEMENT

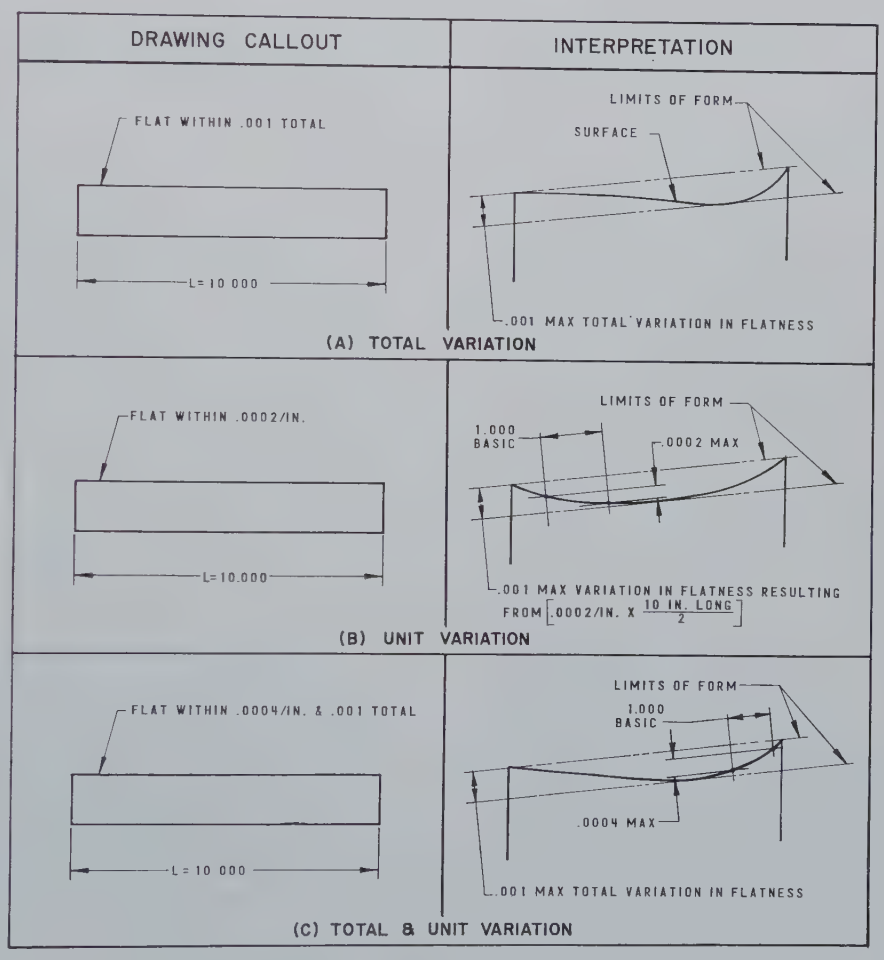

FIG.4 TOLERANCES OF FORM

The errors in form associated with coordinate planes are flatness and squareness. The allowable errors or tolerances of forms may be specified as a unit variation, as a total variation, or as a combination of both. The total variation establishes the maximum and minimum limits of the form of a surface without regard to the rate of the change in the surface. See Fig. 4(A). The unit variation tolerance establishes the maximum change per unit of length with the total variation controlled only by the number of unit lengths in the surface. See Fig. 4(B). In some designs it is necessary to control both total and unit variation; however, the limits of size often adequately control total variation. See Fig. 4(C).

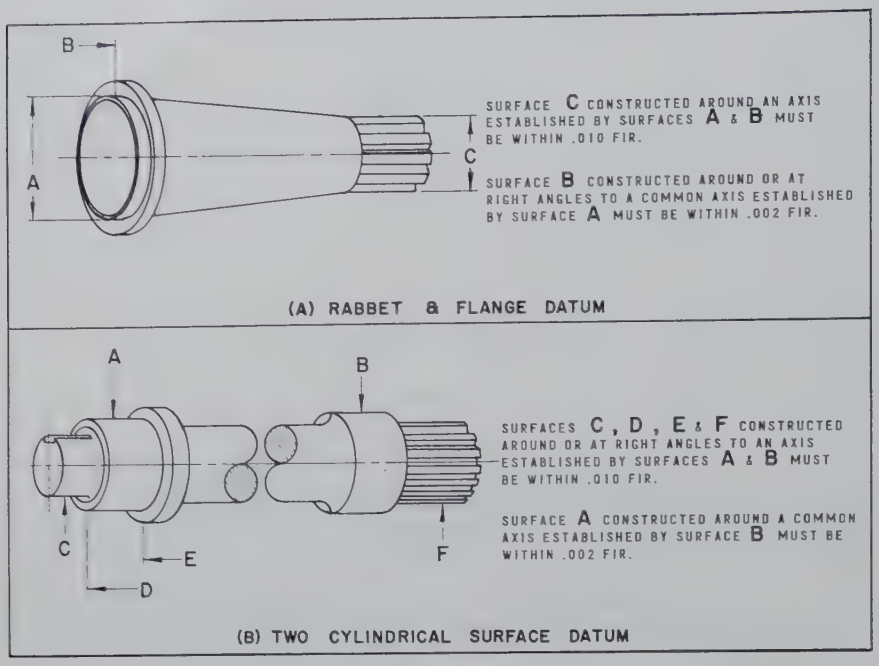

FIG. 5 DATUM AXIS

2. A Cylinder and Plane. Another simple and commonly used datum system is one which makes use of a cylinder and a plane perpendicular to the axis of the cylinder such as a rabbet diameter and a flange as shown in Fig. 5(A). The application of this datum system to a bearing housing and a mating bore in a gear casing is shown in Fig. 6. Surfaces A and B are the mating cylindrical surfaces and surfaces C and D are the two mating planes.

This system is used when it is necessary to control five of the available degrees of freedom to relatively close limits, but the sixth is unimportant. For instance, the two planes C and D prevent rotation of the cover about the axis OX and OY and also translation in the Z direction and thus control three degrees of freedom. The male rabbet A and the hole B control translation in the X and Y directions and thus control two degrees of freedom. The sixth degree of freedom, which is rotation about the Z axis, is not controlled by this datum system, but is limited by the fit between the screws and the holes in the flange. This fit can have wide clearances and tolerances.

3. Plane and Two Noncoincident Cylinders. In this last example, if the design requirement were such that the sixth degree of freedom must be restrained, a single dowel or a body-bound screw could be used. The use of this second noncoincident cylinder which is also perpendicular to the mating plane would restrain the motion about the Z axis.
4. Two Cylinders on Common Axis. In many designs a datum axis is established by two cylinders constructed around a common axis, and having substantial axial separation. As an example of this note the two journal surfaces at each end of the long shaft shown in Fig. 5(B). This type of datum is commonly used to control the runout of surfaces constructed around or at right angles to the common axis.

Accuracy of Datum Surfaces for Form Control

Datum surfaces, like all other surfaces, are subject to manufacturing errors and must be toleranced, and the tolerance of other related surfaces must be decreased to allow for any variations which may exist in the datum surface.

When a surface is to be used as a datum for checking other surfaces or features, the datum surface must first be made sufficiently accurate for such use. When mounted on the datum surfaces, all the designated surfaces including the datum surfaces, must be within the limits specified. In other words, the specified form tolerance for any given surface cannot be increased to allow for any variation which may exist in a datum surface.

Whenever a plane datum surface or mounting plane is referred to on a drawing, the plane is established by the contacting points of the datum surface with a reference plane surface such as a surface plate or checking device.

Since the datum surfaces in a non-rigid structure may vary from the specified drawing tolerances when they are in the free state, it is necessary to specify their maximum allowable free state variation or the maximum forces necessary to restrain them to drawing tolerances. In order to determine the restraining forces required to simulate assembly conditions it is necessary to analyze the mating surfaces and the clamping, bolting, or other forces which will be utilized at assembly to fit the part into its intended application. These calculated forces can be checked and proven during pilot line production by measuring and recording torques and other forces which are used at assembly. Subsequent experience in production will detrmine if it is necessary to modify the engineering requirements specified on the drawing to simulate assembly conditions.

(To be Continued)

The Author

Peter G. Belitsos, supervisor of standards engineering, Large Jet Engine Department, General Electric Co., Cincinnati 15, Ohio, is a graduate of Northeastern University with a B.S. in Engineering and Management. Mr. Belitsos is a member of Society of Automotive Engineers and Standards Engineering Society. He is chairman of the SAE Aero-Auto Drawing Standards Committee, and a member of the Defense Department Drawing Practice Industry Advisory Committee, and the ASA Y14-5 Dimensioning Committee. He received SAE Technical Board Certificate of Appreciation for contributions to drafting standardization.

New Products

Drawing Board Cover

An extra-resilient vinyl plastic drawing board cover is now being marketed by Unitech Corp., 50 Colfax Ave., Clifton, N. J. Designed to overcome the problem of markings left by compass points or sharp-edged instruments, this cover, called Borco, recovers from impressions so quickly that marks tend to disappear in a matter of minutes. Its two surfaces, one soft green, one ivory, are equally usable, have non-glare finish to reduce eye strain. The plastic surface can be washed to maintain its brightness.

File Control System

A completely new system for filing and retrieval of correspondence and other documents has been developed by Recordak, Subsidiary of Eastman Kodak Co., 415 Madison Ave., New York 17, N. Y. Basically, the system involves microfilming of document, recording of indexing information on a pre-punched tab card, and storage of microfilm in magazine form. Retrieval is accomplished by reference to indexed tab card file and thence to microfilm file where document is stored. A reader-printer then supplies data and/or an expendible facsimile.

Hamilton Introduces New Drafting Table

A completely new design based on the Auto-Shift principle is announced by Hamilton Manufacturing Co., Two Rivers, Wisc. Called Torsion Auto-Shift, the new table combines productive efficiency and contemporary styling.

The Torsion Auto-Shift provides complete adjustability of board position and puts every square inch of drawing within easy reach, letting the draftsman work in a comfortable, fatigue-reducing position. An exclusive new tilt mechanism allows complete board counterbalance. The counterbalance is easily adjustable to provide for additional weight of drafting machines.

The combined drawing and reference facilities are designed to save floor space and are accessible from either side.

Precision Measuring Tapes

A new line of fine precision measuring tapes has been introduced by Koh-I-Noor, Inc., Bloomsbury, N. J. The tapes are made in England, come in quality leather cases, with a precision rewind mechanism. Both metallic and non-metallic, the plastic-coated, woven linen tapes in 50- and 100-foot lengths are graduated in feet, tenths, and half-tenths; also in feet, inches, and quarter-inches. Descriptive material on these tapes is available through the importer.

Pencils and Leads for Film

A new line of drawing pencils and leads for use on Mylar, Estar, and Cronar polyester base drafting films has been announced by Richard Best Pencil Co., Inc., Mountain Ave., Springfield, N.J.

The Damascus Polyfilm pencil is available in five degrees of hardness and features Try-Rex, the exclusive Damascus pencil shape. Polyfilm leads are also available in the same five degrees. A free sample set of pencils is available by writing the manufacturer.

Vertical Drawing File

A sturdy mobile file for drawings and prints is announced by Plan Hold Corp., 5204 Chakemco St., South Gate, Calif. Called Mobile Plan Rack it has a tubular steel frame and is equipped with ball bearing casters.

The file can be adjusted to accommodate sheets up to 36″ by 48″. It is intended for use with 12 Plan Hold Type S binders and has a capacity of up to 1,200 sheets. Priced at $19.95 the file weighs less than 18 lbs. and occupies only 3 square feet of floor space.

Color Coded Papers

Increased flexibility for color coding in engineering and business systems is offered by the Ozalid Division of General Analine and Film Corp., 514 Corliss Lane, Johnson City, N. Y. A wide variety of tinted sensitive papers are now available for both Ozalid dry and Ozafax semi-dry diazo printing process, including tints in the new Ozafax super high speeds. Beater dyed during manufacture, the tinted papers are claimed to keep their color for life. A booklet, "Color Says So Much," listing advantages of color coding and color papers, is available from the manufacturer.

(For additional information regarding the new products described here, contact the manufacturer directly. Complete addresses are included.)

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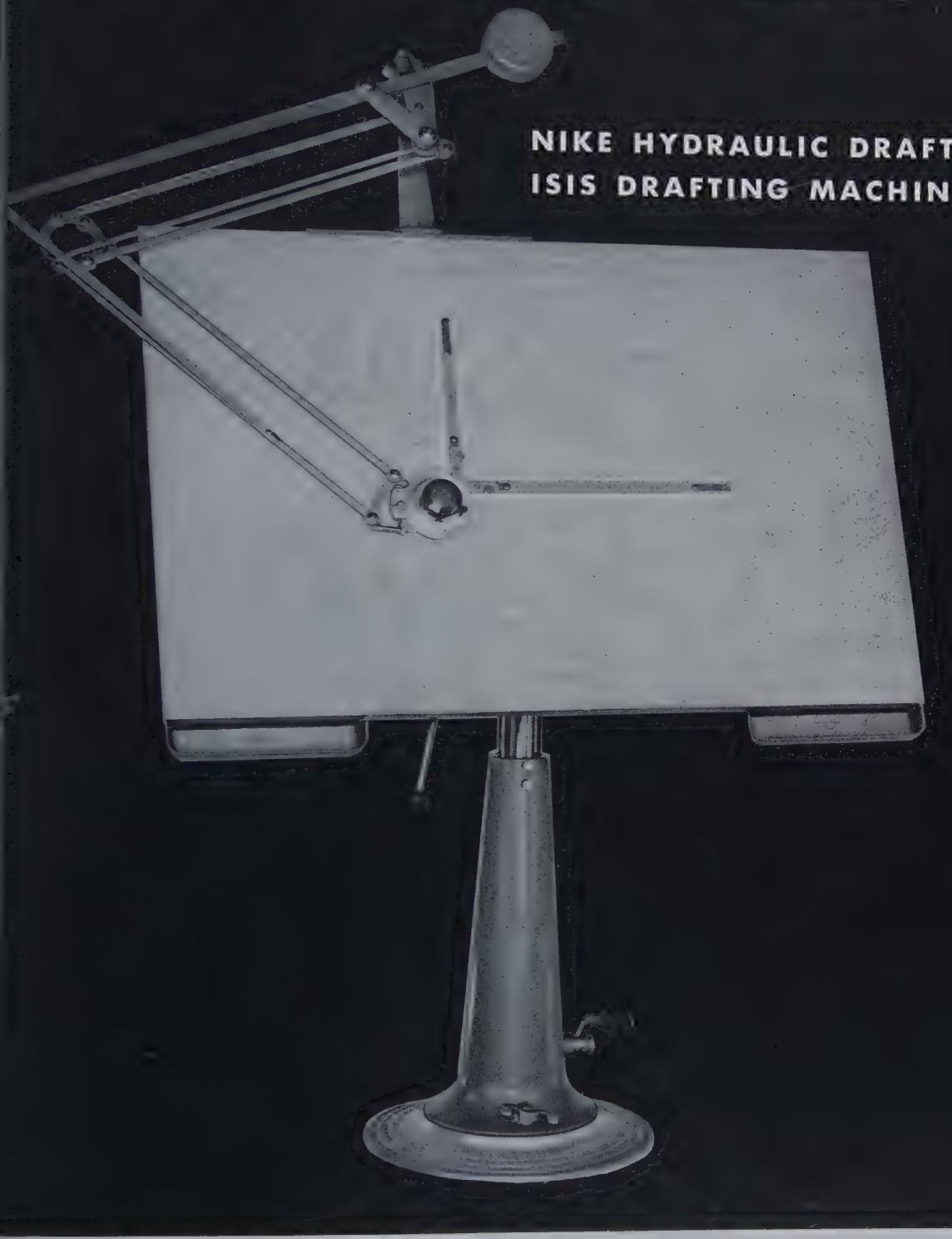

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Portable Drawing Equipment

A new concept in portable drawing equipment has been introduced by Country Engineering, Inc., 20 Blueberry Lane, Darien, Conn. The pocket Polyangle, with a standard pad, gives complete drafting facilities anywhere, adjusts to a pad for accurate field sketching, folds to pocket size in a carrying case when not in use. Main scale slides to provide parallel horizontal lines; spring-loaded angle arm can be snapped into position of 30, 45, 60, 90, 120, 135, and 150 degrees above or below the horizontal. Made of high strength polystyrene and colored in contrast to the pad, the Polyangle complete sells for $1.95.

Angular Label Holders

To prevent stooping and backaches and to provide easier visability for file drawer labels, an angular label holder has been put on the market by File-Aid Card Holders, 7101 Carlsen Ave., Indianapolis 24, Ind. File-Aid label holders come in different sizes to fit into existing frame openings, easily snap into frame. Card and shield to fit slide in and out without removing holder from frame. The shields keep label cards clean and legible.

Mercury Vapor Lamp

A short arc mercury vapor lamp suitable for 35 mm. film reproduction has been announced by Photo Print Equipment Dept., Hanovia Lamp Div., Engelhard Hanovia, Inc., 100 Chestnut St., Newark 5, N.J. The lamp will operate at any wattage between 140 and 400, can be used at 500 watts for short periods of time.

Open-type Drawing File

A new open-type steel filing cabinet for filing engineering drawings, blueprints, and maps, Stikfile Model OC-2224, complete with 22 binders, 24″ in length—has been just added to the line of the Dancer Stikfile Co., P.O. Box 10221, Houston 18, Texas. The cabinet accommodates prints up to 24″ x 36″. The binders hold from 1 to 75 prints each; total capacity, 1650 prints. The cabinet is 36″ wide x 42″ high x 26″ deep. It is sturdily constructed of all-welded heavy gauge furniture steel. Model OC-2224 is available in gray, brown, beige, green, or mist green.

Multi-Copy Process

A new photocopy process that yields up to four copies from a single negative was announced this month by Ampto, Inc., subsidiary of Anken Chemical and Film Corp., Newton, N. J.

Utilizing special Multi-Copy negative and positive papers and Multi-Copy transfer solution, the process can be used with any standard copying machine of the diffusion transfer type.

A prime feature of the process is that four Multi-Copies can be made for less than 20¢ as compared with 34¢ for the same number of standard transfer copies. And because four positive copies can be made in less than one minute it substantially reduces the time required for making four standard copies.

The fourth copy is as photo-exact as the first, whether the originals are letters, reports, orders, invoices, drawings, spec sheets, or other printed matter.

Ampto's new Multi-Copy positive and negative papers are priced the same as standard transfer papers and single copying precedures will cost the same. The economies are effected when two or more copies are made because the same negative is used by reprocessing.

New Aperture Card

Greater contrast and clarity in third and fourth generations of duplicate microfilm aperture cards is a result of a newly developed Duplicard announced by Microfilm Products, Minnesota Mining and Manufacturing Co., 900 Bush Ave., St. Paul 6, Minn.

The new card, used for making duplicates of original Filmsort brand aperture cards, employs a new type of diazo film which produces clearer images on reader screens as well as sharper prints in most processes than possible on any previously available diazo film.

The new card is designed for use in 3M's new automatic aperture card copier, the Filmsort Uniprinter 041 which produces the Duplicards at a rate of 2,000 an hour while requiring a minimum of manual control and only periodic attention during the operation.

Orange in color, to distinguish it from the buff white original card, the standard Duplicard is of quality stock paper and is edge-coated to prevent fraying. According to 3M, it replaces the Duplicard REF.

Since the new standard Duplicards can be run through greater numbers of reproduction generations, broader distribution of information in aperture card format is now possible. For example, punched and interpreted Duplicards in decks can be sent to remote or decentralized areas for point-of-use files of engineering data or published information. From these decentralized files, disposable Duplicard copies can be supplied inexpensively on a demand basis.

Price of the standard Duplicards is less than five cents each. Duplicards are available in the customer's format, the company said. Cards carrying other types of diazo films are still available on a special-order basis.

High-speed Diazo Machine

High capacity output for letter-size copies—more than 3,000 per hour—cut to size and stacked, characterizes the new Copyflex Model 61 diazo reproduction machine developed by Charles Bruning Company, Inc., Mt. Prospect, Ill.

In one continuous operation the fully automatic Model 61 integrates basic printing, cutting, and stacking functions. It's designed to meet demand for high volume production output of both letter-size, and 11- by 17-inch copies.

After an original is positioned automatically in the machine, a control knob is set to the desired number of copies and the machine automatically prints and cuts them to preselected size from a 500-hard roll of 17-inch sensitized paper.

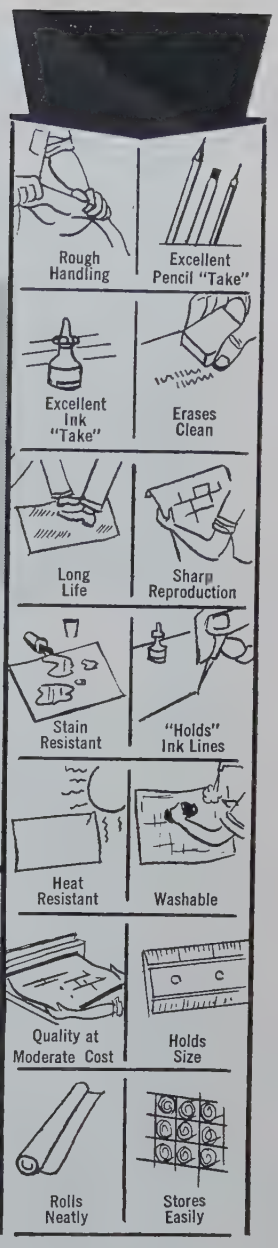
Letter-size reproductions are achieved by an automatic slitting device which perforates the 17-inch-wide roll lengthwise. In this operation duplicate originals are fed into the machine side-by-side.

For continuous copying needs, the Bruning Copyflex Model 61 automatically ejects one set of originals at the end of a production run, inserts another and without interruption produces copies in preset quantities.

Styled in a modern baked enamel finish of neutral tone, the Model 61 stands 47¼ inches high, is 35½ inches wide and 94½ inches long. Front and rear delivery and receiving or stacking trays are at waist level. The new model retails at $9,562.

NEW

ELLIOTT



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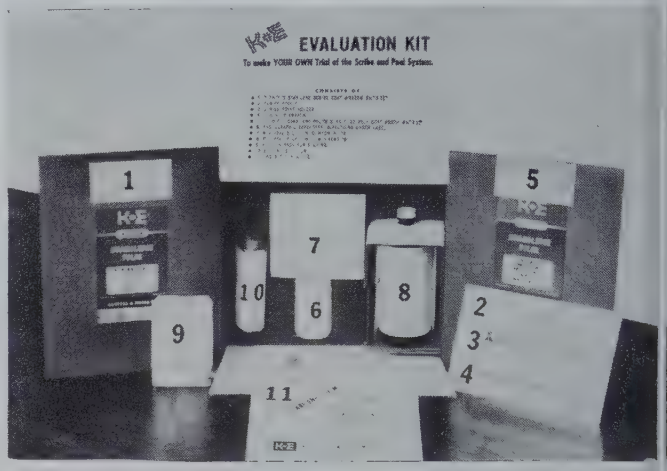
Scribe 'N' Peel Test Kit

A low-cost kit containing enough materials to make a limited number (three or four) map or printed circuit masters by the Scribe 'N' Peel method is announced by Keuffel & Esser Co., Third & Adams Sts., Hoboken, N. J.

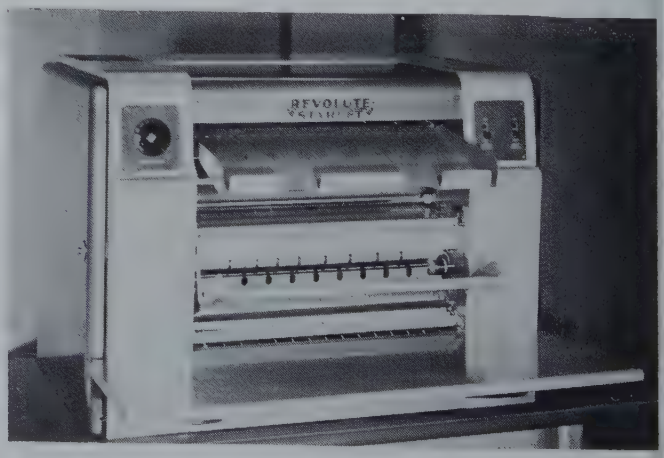
The purpose of the kit is to introduce the new method and enable users to make up samples so they may compare its costs and advantages with other methods.



Contents of the evaluation kit include three sheets of Stabilene Scribe Coat, scribe points, scribe point holder, touch-up crayon, six sheets of Stabilene Photosensitized Peel Coat, photographic developer, reversal solution, four cloth pads for etching, etching solution, and complete instructions.

High Speed Table Model Whiteprinter

Incorporating all the features of larger, higher-priced diazo copying machines, the new table model Startlet 60 introduced by Paragon Revolute Div., Charles Bruning Co., 1800 W. Central Road, Mount Prospect, Ill., will copy engineering drawings up to 20″ wide. It will operate at speeds up to 55 linear feet per minute.



An air-knife system is used to pull the tracing and print off the revolving glass cylinder in the exposure section. The tracing and print are automatically separated by air suction which delivers the tracing to a front receiver. The print is held to the conveyor bands by air and conveyed through the developing section. Copies are automatically stacked in the front receiving tray.

New Literature

One Hundred Answers to the one hundred most frequently asked questions about reproduction and drafting processes and materials are supplied in a new six-page brochure put out by Keuffel & Esser Co., Third and Adams Streets, Hoboken, N. J. Subjects covered include: types of viewing equipment available for 105 mm. and 35 mm. negatives; the main function of an engineering miniaturization system; what the washable tracing technique is; what diazo coatings are available on a polyester film base; the effect of humidity or moisture on diazo papers.

Printed Circuit Drafting Aids Chart, put out last fall by Ky-Buk Co., 4314 West Pico Blvd., Los Angeles 19, Calif., and so popular that the supply was exhausted, is again in print. The copyrighted six-page illustrated table includes all the pre-cut pressure-sensitive shapes and narrow tapes required to make paste-up printed circuit drawings to conform to military, and non-military, specifications; it also gives information on purposes for which different kinds of pressure-sensitive tapes are commonly used on printed circuit drawings and for making prototypes. Charts are available free from the company.

Redstone Arsenal Microfilm Operations are described in an eight-page illustrated booklet put out recently on the operations of the engineering documents section of the United States Army Rocket and Guided Missile Agency (ARGMA), Redstone Arsenal, Huntsville, Ala. A reprint from a recent magazine article, it describes the instant mechanical retrieval of engineering drawings on Filmsort aperture cards from a file of over two million drawings, 750,000 of which are active records. Included is a complete description of retrieval, card-to-paper or card-to-card "print-out" and distribution of engineering drawings, and results of this program in the saving of dollars and time. Copies of the booklet are available free by writing Microfilm Products, Dept. SL-121, Minnesota Mining and Manufacturing Co., 900 Bush Ave., St. Paul 6, Minn.

Precision Instrument Components Standard is the title of a new loose-leaf manual available at no charge to chief draftsmen, chief engineers, and certain others. The material is produced on reproducible tracing paper, 8½ by 11" and consists of over 400 loose-leaf pages in a leather-bound ring binder. Requests for the manual must be made on company stationery to PIC Design Corp., sub. of Benrus Watch Co., Inc., 477 Atlantic Ave., East Rockaway, L. I., N. Y.

Drafting Room Planning Guide in 32 illustrated pages shows equipment advances in the engineering field designed to reduce fatigue, increase individual efficiency, and save floor space. Published by Hamilton Manufacturing Co., Two Rivers, Wisc., the booklet presents a new idea for filing rolled tracings, shows a variety of drafting tables with changeable board positions, gives space-saving layout positions for incorporating tables and other equipment into offices and work rooms.

Blueprint Barricade

ENGINEERING DEPARTMENTS could well use a blueprint to find their way out of the maze of records that is blocking efficiency and increasing costs. That's one conclusion of a survey of 500 top business firms conducted by Charles Bruning Co., Inc., Mt. Prospect, Ill.

The survey queried the executives in charge of engineering reproduction in the nation's top firms to gauge the extent of the problems involved in engineering paperwork — specifically the problems involving drawing reproduction, storage, filing, microfilming, and certain factory paperwork systems.

Herbert Bruning, president, reported that nearly 70 percent of the respondents cited storage of drawings as the principal problem. More than half reported cost of prints as an area of major concern. Other troublesome spots included factory production control paperwork and parts inventory control paperwork.

When asked how they felt about the present status of their company's engineering methods, the respondents were unanimously dissatisfied with the efficiency of their paperwork system.

More than 60 percent viewed filing and storage as the area presenting the greatest challenge. More than half pinpointed it to drawing and print accessibility, while a substantial percentage viewed reduced size of reproductions and faster reproduction processes as paramount challenges.

More than 50 percent of the respondents indicated they would take some steps to improve engineering reproduction systems in 1961. Emphasis will be placed on consideration and installation of microfilming procedures and on new or additional installation of reproduction equipment. Over 27 percent said they would explore or install microfilming procedures. Another 16 percent plan to install new reproduction equipment, particularly diazotype whiteprint equipment. Others will concentrate on new or improved filing systems and emphasize consolidation and closer control of existing equipment and procedures.

A preponderance of respondent (61.4 percent) indicated they woul turn to suppliers of copying machine and systems equipment for counsel i revising engineering paperwork pro cedures; 35.3 percent said they woul call on business associates, friends o acquaintances for aid as well. Onl 12.6 percent would call in manage ment consulting organizations.

When asked what drawing mediu they preferred, the respondents indi cated paper, film, and cloth, in tha order. More than 26 percent an swered that they used paste-u drafting techniques.

Of those companies with a minia turization program in effect, the ma jority chose microfilm as the mean Despite indications that miniaturiza tion is the most effective method o solving the problem of handling an storing engineering drawings, the sur vey indicates that few companie (18.8 percent) have as yet actuall adopted a miniaturization progra

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LATEST WORD FROM MARS is the superb new Technico lead holder—with clear-view degree indicator placed right at your fingertips. Contoured for perfect balance, with new positive finger grip, it's the newest of many fine MARS drafting aids—all designed to make your work easier, and to make it look better and reproduce better.

Among the famous imported Mars drafting products are: the Mars-Technico push-button lead holders (with adjustable degree indicator*, with specific degree imprint, the economy model*); Mars-Lumograph drawing leads*, 18 degrees, EXB to 9H; Mars-Lumograph drawing pencils, 19 degrees, EXEXB to 9H; Mars-Duralar pencils and leads for drafting on Mylar® -base drafting film —5 special degrees, K1 to K5; Mars-Duralar Technicos with adjustable Duralar degree indicator; Mars-Lumochrom colored drawing pencils, 24 shades. Also: Mars Pocket-Technico for field use; Mars pencil and lead sharpeners; Mars Non-Print pencils and leads; Mars-Duralar erasers. Mars products are available at better engineering and drafting material suppliers everywhere.

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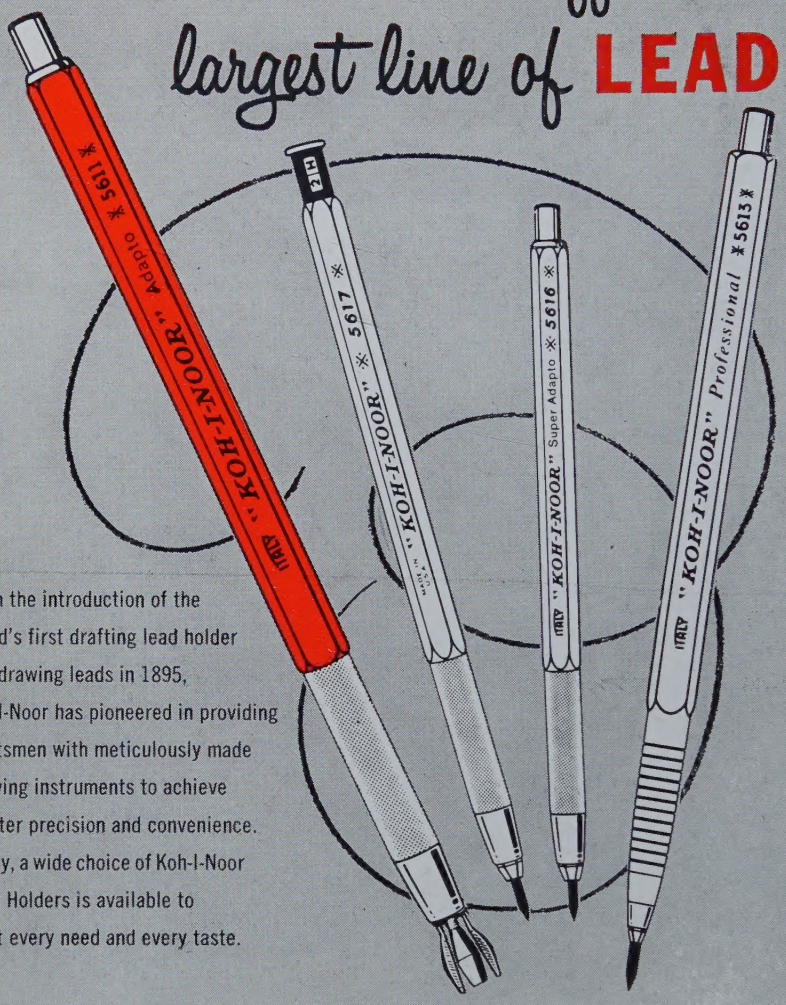

From the introduction of the world's first drafting lead holder and drawing leads in 1895, Koh-I-Noor has pioneered in providing draftsmen with meticulously made drawing instruments to achieve greater precision and convenience. Today, a wide choice of Koh-I-Noor Lead Holders is available to meet every need and every taste.

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No. 5617—Non-slip, non-turn "Adapto-Clutch" takes all diameters in 17 degrees of lead. Push button control has built-in degree indicator. Perfectly balanced, with knurled finger grip.

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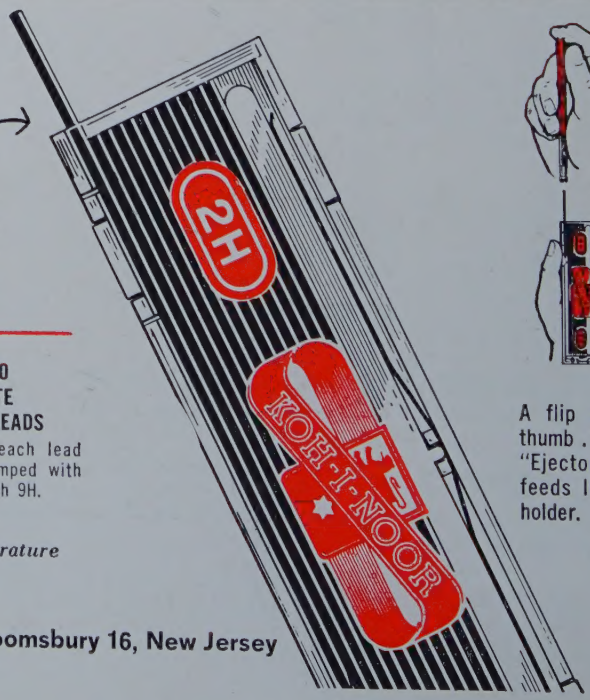
LEAD DISPENSER
A flip of the thumb feeds lead from this compact plastic dispenser to the holder, cleanly without need to touch lead. Available in 17 degrees of graphite and 9 colors.



A flip of the thumb . . . and "Ejectomatic" feeds lead to holder.

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